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THE SPEED OF GERMICIDAL ACTION OF CHLORINE COMPOUNDS UPON BACTERIA COMMONLY OCCURRING IN MILK.

C. K. Johns *

Central Experimental Farm, Ottawa, Ont.

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Introduction

The possibilities in the employment of certain chlorine compounds for the sterilization of dairy utensils and equipment have recently received considerable attention. Backed by the reported results of various workers (*2, 3, 6, 8, 9, 10, 12, 13*), manufacturers have been active in creating a market for their products, and the practice of chlorine sterilization, both on the farm and in the dairy plant, has grown quite rapidly. Where a chlorine rinse is employed in the sterilization of dairy utensils on the farm, the period of contact between the solution and the surface of the utensil is necessarily brief ; consequently, the speed with which the bacteria are destroyed becomes of paramount importance. While some work dealing with this phase of the subject has been reported (*8*), it has been of limited value to the dairy farmer since the effectiveness of periods of exposure less than one minute has not been studied. In order to obtain some information covering this point, the investigation reported here was commenced as a continuation of studies on methods of utensil sterilization, the first series of which has already been reported (*6*).

Methods

For the purpose of this investigation the following four representative proprietary compounds were obtained :—

B-K—liquid sodium hypochlorite.

Diversol—sodium hypochlorite combined with tri-sodium phosphate.

Santamine—chloramine-T powder.

Sterilac—chloramine-T powder.

In addition, a home-made concentrated solution of sodium hypochlorite (made from chlorinated lime) was included for comparative purposes. The commercial products were diluted before using in accordance with the directions on the package*, while the dilution of home-made hypochlorite was arranged to provide a rinse containing approximately 65 parts per million available chlorine at the start of the experiments.

An attempt was first made to determine the value of the above products by means of a series of can rinsing experiments. Although valuable informa-

*Assistant Agricultural Bacteriologist.

*In order to obtain countable plates it was found necessary to increase the concentration of Sterilac to 6 times that recommended by the manufacturers. In the case of Diversol, since contradictory statements appeared on the container, this product was used in the same concentration as B-K, i.e., 1 part to 384 parts water. This really gives Diversol some advantage since the latest directions issued by the manufacturer specify a dilution of 1 part to 512 parts water.

tion was gleaned from this work, it was felt that such studies might well be supplemented by experiments where there were fewer variable factors beyond the control of the experimenter. In the development of a suitable method it was considered most desirable that information should be afforded as to the relative speed of germicidal action of the five products, and that this information might be expressed as the percentage survival of bacteria after varying periods of contact. These conditions were found to be reasonably well satisfied by the method here described; A 200 c.c. quantity of sterile tap water at room temperature was measured into a 500 c.c. sterile stoppered Erlenmeyer flask, and the required amount of chlorine compound added. Upon the completion of preparations for the rapid pouring of plates, the chlorine solution was inoculated with 1 c.c. of bacterial culture or suspension.* After shaking vigorously for 7 seconds, 1 c.c. of the solution was withdrawn and delivered into the first petri dish. Fifteen seconds from the moment of inoculating the chlorine solution in the flask, 10 c.c. of nutrient medium was poured into the petri dish and mixed with the 1 c.c. of solution previously introduced. Additional plates were similarly prepared at 15 second intervals over a period of 60 seconds for the hypochlorites and 120 seconds for the chloramine-T products. This procedure was repeated for all five chlorine products. Nutrient media and temperature and period of incubation were varied to suit the particular organism being studied.

The percentage survival of bacteria after the various periods of contact with each of the five chlorine products was calculated by dividing the number of bacteria present in 1 c.c. of the diluted culture used as inoculum (plate counts of which had been made concurrently) by 200 to determine the number originally introduced per c.c. of sterilizing solution, then dividing the plate count of surviving bacteria by the previous quotient and multiplying by 100 to express as percentage survivors.

It will be readily observed that in the plating method described, it is assumed that upon pouring the plate and mixing the nutrient medium with the 1 c.c. of inoculated chlorine solution, the germicidal activity of the chlorine compounds ceases. The validity of this assumption was tested out in the following manner: Concurrently† with the pouring of the plates, a loopful of the chlorine solution inoculated with *S. lactis* was introduced into 10 c.c. of sterile purple milk. Here the quantity of chlorine present in relation to the organic matter content of the milk is so extremely small as to assure any viable bacteria introduced into the milk an excellent chance of further survival and growth. The data obtained for the two liquid hypochlorites as given in table 1 indicate that in the case of these compounds there is no reason for doubting the correctness of the results obtained with the plating method. In the case of Diversol, the high percentage of surviving bacteria in subsequent tests (see table 6) does not support the possibility of significant germicidal action subsequent to the pouring of the plate.

*In all work with pure cultures a preliminary estimate was made by means of the Breed method (*1*). Based on this estimate, the culture was diluted with sterile water to avoid too great overcrowding of the plates poured after the shorter periods of contact. In addition, by this means the quantity of organic matter from the broth which was introduced into the sterilizing solution was reduced to .0004 per cent or lower.

†The author is indebted to Mr. N. B. McMaster, B.S.A., for assistance in the milk innoculation tests reported here.

TABLE 1. *Validity of plating method in measuring sterilizing value of liquid hypochlorites.* (*S. lactis*)

Trial No.	B-K				Home-made NaOCl			
	15 seconds contact		30 seconds contact		15 seconds contact		30 seconds contact	
	Plate count	Milk tube	Plate count	Milk tube	Plate count	Milk tube	Plate count	Milk tube
1	0	—	0	—	0	—	0	—
2	0	—	0	—	14	+	0	—
3	0	—	0	—	0	—	0	—
4	0	—	0	—	0	—	0	—

\+ = curdled in 3 days at room temperature.

In the case of the chloramine-T products, however, it was expected that in view of their greater stability in the presence of organic matter, a continuation of germicidal action after the pouring of the plate would be encountered. However, a number of tests performed on a representative chloramine-T (Santamine) failed to show any substantial difference between the results of milk tube inoculations and plate counts.

TABLE 2. *Validity of plating method in measuring sterilizing value of chloramine-T.* (*Santamine*) (*S. lactis*)

	Number of seconds contact									
Plate Counts	15	30	45	60	75	90	105	120	135	150
Trial No. 1	1080	1740	340	140	60	28	sp.	2	0	0
2	1650	sp.	93	21	39	sp.	2	1	0	0
3	2470	960	720	154	96	102	75	sp.	38	sp.
4	1020	2100	sp.	188	36	42	8	8	9	2
5	sp.	1416	516	340	64	sp.	18	18	11	sp.
6	2200	790	630	sp.	sp.	231	44	sp.	sp.	0
7	1800	660	14	9	7	2	1	3	1	0
8	1140	sp.	sp.	sp.	2	0	1	0	0	0
9	1600	sp.	328	160	52	sp.	0	0	0	0
10	69	70	66	32	22	23	2	sp.	5	2
11	52	6	2	0	0	0	0	0	0	0
12	64	79	sp.	11	sp.	3	0	0	0	0
13	86	76	15	5	0	1	0	0	1	0
14	234	153	54	2	0	4	0	0	0	0
Average count*	1036	732	253	89	32	39	12	3	5	0.3
Milk tubes curdled in 48 hours at 20° C.										
Trial No. 1	+	+	+	+	−	−	+	−	−	−
2	+	+	+	+	+	−	−	−	−	−
3	+	+	+	−	−	−	−	−	−	−
4	+	+	+	−	−	−	+	+	+	−
5	+	+	+	+	+	+	+	+	+	+
6	+	+	+	+	+	−	−	−	−	−
7	+	+	+	+	−	−	−	−	−	−
8	+	+	+	−	−	−	−	−	−	−
9	+	+	+	−	−	−	−	−	−	−
10	+	+	+	+	+	−	−	−	−	−
11	+	+	−	−	−	−	−	−	−	−
12	+	+	−	−	−	−	−	−	−	−
13	+	+	−	−	−	−	−	−	−	−
14	+	+	−	−	−	−	−	−	−	−
Total curdled tubes	14	14	10	6	4	1	3	2	2	1

\+ = curdled
*Spreader plates excluded

In view of the foregoing data it would appear that the plating method may be relied upon to yield substantially correct results with both hypochlorites and chloramines.

Experimental

Having established the validity of the plating method as described above, the method was applied to a study of the effectiveness of the five chlorine compounds in the destruction of certain organisms commonly occurring in market milk. Included in this study were mixtures of organisms obtained from milk cans, gas producing bacteria (*Esch. coli* and *Aerobacter aerogenes*), the common milk souring organism (*S. lactis*), and the spore forms of *B. subtilis*.

SERIES 1.

Effectiveness of Chlorine Compounds Against Mixtures of Organisms Obtained from Milk Cans

In this series of tests, 6 cans which brought the evening's milk to the dairy were allowed to remain unwashed overnight at room temperature. Next morning they received a rinse with cold water, followed by a thorough brushing with hot water containing dairy cleanser. After being inverted to drain for a minute or two, the lids were replaced and cans remained at room temperature. After 5 hours, 200 c.c. of sterile tap water was poured into the first can and the can manipulated to bring the rinse into contact with the entire inner surface. This rinse water was then poured into the second can, and the process repeated until the rinse finally recovered represented the contamination from all 6 cans. This rinse was then allowed to incubate overnight at room temperature and was used next morning as inoculum for solutions of the chlorine products. In this series, standard nutrient agar (Difco) was employed and the plates incubated for 48 hours at 37°C. While the presence of spreaders on a considerable percentage of the plates poured affected the accuracy of counting, yet when the figures obtained in 11 tests are averaged (table 3) it will be seen that the products studied varied considerably in the rate at which the mixtures of bacteria were destroyed. In the case of the liquid hypochlorites, all but a few spore-forming types had been destroyed within 15 seconds. Diversol was noticeably slower acting, leaving many more bacteria surviving after 60 seconds than remained after 15 seconds contact with the liquid hypochlorites. As was to be expected, the two chloramine-T compounds were the slowest, with Sterilac decidedly poorer than Santamine even when employed in sextuple strength.

Table 3. *Percentage of bacteria (mixed organisms from cans) surviving treatment with chlorine solutions. (Average of 11 tests.)*

Number of seconds contact	B-K	Home-made NaOCl	Diversol	Santamine	Sterilac (x6)
15	0.0051	0.0204	2.95	6.41	10.9
30	0.0034	0.0243	0.917	3.65	9.70
45	0.0050	0.0224	0.522	2.56	5.96
60	0.0043	0.0273	0.183	1.23	7.19
75				0.647	6.40
90				0.336	6.06
105				0.280	8.74
120				0.394	9.78

SERIES 2.

Effectiveness of Chlorine Compounds Against *Esch. coli.*

The organism employed in this series was a typical strain of *Esch. coli* isolated from feces. It was grown in nutrient broth for 18 hours at 37°C., suitably diluted with sterile water and used as inoculum for the chlorine solutions. Plates were poured using nutrient agar (Difco) and incubated for 48 hours at 37°C. The data obtained as the average of 12 tests are given in table 4, where it is evident that Diversol was considerably more effective against *Esch. coli* than against the mixed organisms employed in Series 1. Sterilac was also more effective here, although Santamine was somewhat more effective against the mixed organisms. The latter, while far behind the hypochlorites, still showed itself superior to its fellow chloramine-T when the latter was used in sextuple strength.

Table 4. *Percentage of bacteria (Esch. coli) surviving treatment with chlorine solutions. (Average of 12 tests).*

Number of seconds contact	B-K	Home-made NaOCl	Diversol	Santamine	Sterilac (x6)
15	0.0	0.0	0.0006	10.1	10.6
30	0.0	0.0	0.0	6.07	7.45
45	0.0	0.0	0.0	3.09	6.93
60	0.0	0.0	0.0	1.88	4.46
75				1.51	4.41
90				1.06	3.61
105				0.717	2.31
120				0.621	1.78

SERIES 3.

Effectiveness of Chlorine Compounds Against *Aerobacter aerogenes.*

The organism employed in this series was one isolated from a milking machine during a study of types of organisms present in machine-drawn milk. It was grown in nutrient broth at 37°C. for 18 hours, suitably diluted and used as inoculum. Plates were poured and incubated as in Series 1 and 2. The averages of the results obtained in 10 tests are given in table 5. Here again the liquid hypochlorites showed a slight advantage over Diversol and a much greater one over the chloramines. Santamine is somewhat more effective than against *Esch. coli,* while Sterilac shows little difference. The latter is again decidedly less effective than Santamine.

Table 5. *Percentage of bacteria (Aer. aerogenes) surviving treatment with chlorine solutions. (Average of 10 tests).*

Number of seconds contact	B-K	Home-made NaOCl	Diversol	Santamine	Sterilac (x6)
15	0.0	0.0	0.00696	7.17	15.6
30	0.0	0.0	0.0	3.68	9.75
45	0.0	0.0	0.0	1.01	7.37
60	0.0	0.0	0.0	0.436	4.04
75				0.300	2.64
90				0.108	2.56
105				0.0412	2.28
120				0.0330	1.85

SERIES 4.

Effectiveness of Chlorine Compounds Against *S. lactis.*

The organism employed in this series was isolated from buttermilk from starter cream. For the first few tests it was grown in lactose broth at 30°C. for 24 hours, but since growth in this medium was rather slow, whey broth containing powdered $CaCO_3$ was used for subsequent tests. With the latter medium growth was much more vigorous. Plates were poured using purple lactose agar (Difco), and incubated for 5 days at ± 20°C. The averages of the results obtained in 18 tests are presented in table 6. It will be seen that this organism proved to be much more resistant to Diversol and the chloramines than the gas-producing bacteria of Series 2 and 3. The liquid hypochlorites were, as usual, most effective.

Table 6. *Percentage of bacteria (S. lactis) surviving treatment with chlorine solutions. (Average of 18 tests).*

Number of seconds contact	B-K	Home-made NaOCl	Diversol	Santamine	Sterilac (x6)
15	0.0	0.0035	26.7	18.9	15.5
30	0.0	0.0	10.6	13.4	13.1
45	0.0	0.0	3.45	7.42	11.5
60	0.0	0.0	1.08	6.67	8.15
75			0.101	3.94	9.59
90			0.0262	4.30	6.78
105			0.0073	1.72	4.14
120			0.0036	2.31	6.14

SERIES 5.

Effectiveness of Chlorine Compounds Against Spores of *B. subtilis.*

In order to determine whether a chlorine rinse was of any value in the destruction of spore forms, two sets of tests were conducted. Nutrient agar plates were streaked with a suspension of *B. subtilis,* incubated at 37°C. for 24 hours and then allowed to stand at room temperature for one week to encourage spore formation. The plates were then flooded with sterile water, the surface growth removed as completely as possible and the bacterial suspension transferred to a test-tube. This suspension was heated in a water bath to 80°C. for 10 minutes to destroy vegetative forms, then cooled and used as inoculum for the chlorine solutions. Plates were poured every 15 seconds up to 120 seconds for all five products, using nutrient gelatin (Difco) and incubating at ± 16°C. for 72 hours. However, in both tests liquefaction was proceeding rapidly by the end of the second day, and a careful estimate of the number of colonies present on the plates failed to reveal any evidence of destruction of spores during the longest period of contact employed (120 seconds). It would appear, therefore, that solutions of these compounds exert little or no influence upon spore forms when the period of contact is as limited as that employed in can rinsing.

Strengths of Sterilizing Solutions Employed

In the tests reported in Series 1 to 4, the various chlorine products were diluted in accordance with the directions appearing on the container*. Since

*As previously explained it was found necessary to increase the concentration of Sterilac to 6 times that recommended.

the stability of these concentrated products is a matter of considerable interest to the prospective purchaser, a summary of the data obtained in determining the available chlorine content of the sterilizing solutions used in the preceding series of tests is given in table 7. It will be observed that the data from

TABLE 7. *Strengths of sterilizing solutions employed.*

		Parts per million available chlorine.				
Series		B-K	Home-made NaOCl	Diversol	Santamine	Sterilac (x6)
1.	Average	86	65	61	106	191
	Maximum	90	67	64	110	—
	Minimum	83	64	58	99	—
2.	Average	79	63	54	108	191
	Maximum	88	69	59	113	199
	Minimum	76	59	48	106	186
3.	Average	77	61	49	107	188
	Maximum	80	63	53	110	200
	Minimum	75	60	45	105	184
4.	Average	76	60	46	106	186
	Maximum	79	64	52	107	188
	Minimum	70	54	42	104	184

each series of tests are presented separately. Since the same dilution was employed for each product in all four series, the progressive decline in strength of the concentrated products is indicated by the changes in strength of the rinsing solutions. Series 1 ran from March 12 to 28, Series 2 from April 2 to 17, Series 3 from April 22 to May 8 and Series 4 from May 10 to June 7. As will be observed from the table, between the averages of the first and fourth periods Santamine showed no change, Sterilac a decline of 2.6 per cent, home-made hypochlorite 8.3 per cent, B-K 11.6 per cent and Diversol 24.6 per cent in available chlorine content. Further analyses conducted upon B-K and Diversol on Oct. 11 gave values of 59 and 27 parts per million available chlorine respectively, showing further declines during the 4 month period of 22.4 per cent and 41.3 per cent respectively from the average figures of Series 4. All five compounds were stored under similar conditions at room temperature, and in the case of the solid forms (Sterilac and Diversol) the required amounts were weighed out on a chemical balance. It would seem, therefore, that the varying losses in strength cannot be charged to anything other than lack of stability in the respective products.

DISCUSSION

From an examination of the data presented in tables 3 to 6, it appears that not only do the different chlorine products tested vary widely in their germicidal efficiency, but also that certain bacterial species show striking differences in their resistance to solutions prepared from the various products. These points are brought out more clearly in table 8, where the comparative effectiveness of the same product against different species of bacteria may be studied more conveniently.

TABLE 8. *Percentage survival of bacteria in sterilizing solutions after varying periods of contact.*
(Summarizing tables 3-6.)

Product		15 Sec.	30 Sec.	45 Sec.	60 Sec.	75 Sec.	90 Sec.	105 Sec.	120 Sec.
B-K	(a) Mixed cult. from cans	0.0051	0.0034	0.0050	0.0043				
	(b) Pure cult. *E. coli*	0.0	0.0	0.0	0.0				
	(c) " " *A. aerogenes*	0.0	0.0	0.0	0.0				
	(d) " " *S. lactis*	0.0	0.0	0.0	0.0				
Home-made NaOCl	(a) Mixed cult. from cans	0.0204	0.0243	0.0224	0.0273				
	(b) Pure cult. *E. coli*	0.0	0.0	0.0	0.0				
	(c) " " *A. aerogenes*	0.0	0.0	0.0	0.0				
	(d) " " *S. lactis*	0.0035	0.0	0.0	0.0				
Diversol	(a) Mixed cult. from cans	2.95	0.917	0.522	0.183				
	(b) Pure cult. *E. coli*	0.0006	0.0	0.0	0.0				
	(c) " " *A. aerogenes*	0.00696	0.0	0.0	0.0				
	(d) " " *S. lactis*	26.7	10.6	3.45	1.08	0.101	0.0262	0.0073	0.0036
Santamine	(a) Mixed cult. from cans	6.41	3.65	2.56	1.23	0.647	0.336	0.280	0.394
	(b) Pure cult. *E. coli*	10.1	6.07	3.09	1.88	1.51	1.06	0.717	0.621
	(c) " " *A. aerogenes*	7.17	3.68	1.01	0.436	0.300	0.108	0.0412	0.0330
	(d) " " *S. lactis*	18.9	13.4	7.42	6.67	3.94	4.30	1.72	2.31
Sterilac (x6)	(a) Mixed cult. from cans	10.9	9.70	5.96	7.19	6.40	6.06	8.74	9.78
	(b) Pure cult. *E. coli*	10.6	7.45	6.93	4.46	4.41	3.61	2.31	1.78
	(c) " " *A. aerogenes*	15.6	9.75	7.37	4.04	2.64	2.56	2.28	1.85
	(d) " " *S. lactis*	15.5	13.1	11.5	8.15	9.59	6.78	4.14	6.14

Although Santamine was at all times superior to Sterilac against non-spore-formers, neither of these two products can be considered suitable for use as an instantaneous rinse. The slowness in feeding out available chlorine which makes chloramine-T so valuable for wound treatments or for sterilizing the rubber parts of milking machines (*5*) renders this type of chlorine compound decidedly less useful in a situation requiring rapid sterilizing action.

Against all non-spore-forming organisms the liquid hypochlorites were practically 100 per cent effective. Diversol, however, while quite satisfactory against the gas-producing species, was less effective against the mixed organisms from cans, and proved surprisingly slow in the destruction of *S. lactis*. This is not in agreement with the statement of Prucha (*9*) that "its (Diversol's) sterilizing power, as measured by the amount of active chlorine, is about the same as that of liquid sodium hypochlorites." Doubtless Prucha based this statement upon the results of his experiments with *Esch. coli* (*8*), against which Diversol is apparently as effective as the liquid products (table 4). This marked resistance of *S. lactis* * toward Diversol is of particular interest in view of the importance of this organism in the dairy world.

From the results obtained with Diversol, it appears that the so-called "available chlorine" content of a hypochlorite may not always indicate by itself the actual germicidal value. Even though the Diversol rinse was somewhat weaker than those prepared from the liquid hypochlorites, this does not account for the vast difference in sterilizing power, since later tests, using Diversol in a concentration of over 70 parts per million available chlorine, have shown the same retardation in the destruction of *S. lactis*. The cause of this remarkable difference is still being investigated, but sufficient data have been obtained (see table 9) to indicate that the tri-sodium phosphate, comprising approximately 94 per cent of Diversol (*4*) is the factor responsible. When tri-sodium phosphate is added to B-K rinse in an equivalent concentration, the sterilizing power and corrosiveness of B-K are strikingly reduced. On the other hand, when a Diversol rinse is adjusted to approximately the same pH value as B-K, it increases tremendously in germicidal power and corrosiveness. This points to the influence of the increased hydroxyl-ion concentration in retarding the activity of the "available chlorine" content.

That the pH of a hypochlorite solution has a decided influence upon its activity has been noted by several investigators. Rideal and Evans (*11*) predicted the retardation of the action of hypochlorite solutions by the presence of alkali on the basis of measurements of oxidation potentials. Wright (*14*) has called attention to the fact that acidity increases chlorination while alkalinity increases oxidation of substances by hypochlorite. Myers (*7*) found neutral sodium hypochlorite decidedly more effective than an alkaline product in the destruction of spores at 60°C. Nevertheless, there is apparently no explanation for this retarding action being so marked in the case of *S. lactis*, while practically unnoticeable with the gas-producing

*Two other strains of *S. lactis* have since been tested out against the hypochlorites, and in all cases have shown similar resistance toward Diversol. In one series over 17 per cent of the organisms survived after 60 seconds contact. (See Table 9.)

TABLE 9. *Percentage of bacteria (S. lactis) surviving treatment with chlorine solutions. (Average of 4 tests with each culture).*

Culture No.	Number of seconds contact	B-K	B-K + 0.245% T.S.P.	Diversol
	15	0.0	37.7	42.6
222	30	0.0	8.68	4.99
	45	0.0	2.76	0.753
	60	0.0	.108	0.005
	15	0.0	24.6	26.9
223	30	0.0	17.9	16.8
	45	0.0	7.89	8.47
	60	0.0	4.74	4.25
		B-K	Diversol + HCl	Diversol
	15	0.0	0.0	52.9
223	30	0.0	0.0	39.4
	45	0.0	0.0	22.6
	60	0.0	0.0	17.7

bacteria. It is possible that this phenomenon is related in some way to the reaction of the organism to the Gram stain (since so far only Gram-positive organisms have shown resistance to Diversol), and further studies will be made in that direction.

SUMMARY

A study has been made of the speed of destruction of mixed organisms from milk cans, *Esch. coli*, *Aer. aerogenes*, *S. lactis* and spore forms of *B. subtilis* by solutions of three hypochlorite and two chloramine-T products.

The liquid hypochlorites were extremely effective against all non-spore-formers; Diversol was effective against the gas-producing species, slower against the mixed organisms from cans , and surprisingly slow against *S. lactis*; while the chloramine-T products in all cases acted too slowly to be considered suitable as sterilizing rinses. None of the five products had any noticeable effect upon the spores of *B. subtilis* during a 2 minute exposure.

The retarded action of Diversol against *S. lactis* is apparently bound up with the higher hydroxyl-ion concentration of solutions made up from this product.

Over a period of three months, the percentage losses of available chlorine from the concentrated products were least with chloramine-T, followed by home-made hypochlorite, B-K and Diversol in the order given.

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STUDIES ON TREE ROOT ACTIVITIES

PART II. SOME FACTORS WHICH INFLUENCE TREE ROOT RESPIRATION *

G. H. HARRIS †

University of British Columbia, Vancouver, B.C.

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In an article which appeared in *Scientific Agriculture,* Vol. IX., No. 9, May, 1929, an apparatus for studying root respiration and factors which influence it (Figure 1) was described by the writer. The history and general behaviour of the young trees used in the experiment, grown in a culture solution in sealed containers were described and the basis given for dividing them into the two groups, normal trees Group I, and starved trees Group II, was discussed.

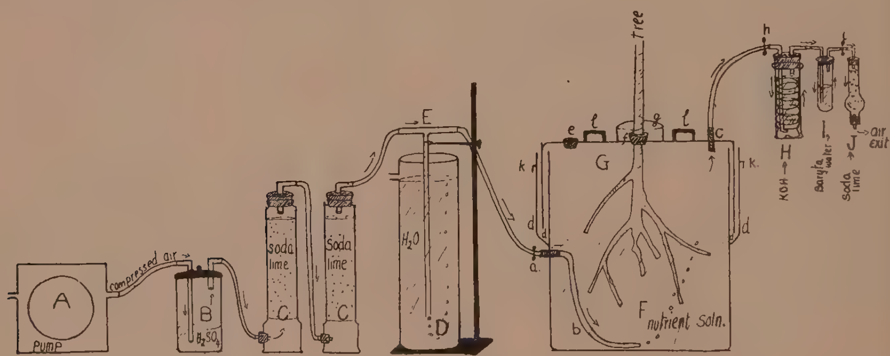

Figure 1. Apparatus used.

The following article deals chiefly with some of the factors which influence root respiration itself as determined by using the above mentioned apparatus.

Before discussing these factors influencing root respiration, it is of interest to note the large amount of CO_2 excreted by the roots of young normal trees as shown in table 1.

Table 1 shows that the weight of CO_2 excreted by the roots of young trees over an eighteen month period amounts to from one-third to more than the same weight of new root growth formed on a fresh weight basis, or two to three times the weight of the new root growth formed, on a dry weight basis. CO_2 has a very definite effect on the soil and soil solution around the roots in changing the reaction and making plant nutrients available. This large amount of CO_2 excreted is therefore an important factor from a soil nutrient standpoint.

That the amount of CO_2 excreted per gram increase in weight of new root growth is fairly constant within a species and differs considerably between species is perhaps significant. It would appear that there is an inherent specific difference in the metabolism of different species of fruit trees.

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†Assistant Professor of Horticulture.

TABLE 1. *Increase in weight and CO_2 excreted by roots of one year old trees during 18 months.*

Tree	Tree No.	Original Weight of Root (grams)		New Roots Formed (fibres) (grams)		Final Weight of Root (grams)		Increase in Weight of Root (grams)		CO_2 Excreted by Roots (grams)	CO_2 Excreted per gram increase in Weight	
		Fresh Weight	Dry Weight	Fresh Weight	Dry Weight	Fresh Weight	Dry Weight	Fresh Weight	Dry Weight		Fresh Weight	Dry Weight
Apricot	4	105	46	102	26	238	102	133	56	152	1.15	2.7
on	5	58	29	155	24	217	80	159	51	166	1.05	3.3
Apricot	6	42	23	116	23	143	72	101	49	167	1.65	3.3
Bing Cherry	7	240	100	418	55	815	221	575	121	203	.35	1.75
on	8	113	37	387	44	577	107	464	70	158	.34	2.25
Mazzard	9	143	54	262	34	463	100	320	46	129	.40	2.84
Hardy Pear	22	122	55	95	21	254	93	132	48	99	.75	2.60
on	23	167	79	73	15	285	115	118	36	103	.87	2.87
Quince	24	165	88	50	12	244	116	79	28	92	1.16	3.28
Bartlett Pear on	25	169	76	142	21	387	131	218	55	152	.70	2.8
Japanese	26	175	80	38	11	256	111	81	31	97	1.20	3.1

Some of the variation within a species is explained in the following discussion of factors which affect root respiration.

Explanation of Terms Used

In connection with the following discussion, reference is made throughout to the data shown in the appendix. The amount of CO_2 excreted by the roots is expressed graphically in grams produced per 168 hours (one week). Under the column headed "operation causing injury", "cleaned cans" signifies that the tree and cover were removed and placed in another container while the original container was scrubbed out and refilled with new solution. "Examined" refers to lifting the cover and tree clear of the solution for detailed examination of the roots and replacing it in the same solution. "Shoot growth" refers to growth in length, "stem thickening" to increase in diameter of the stem due to cambial activity, "base thickening" to increase in diameter at the lowest point measured on the stem (i.e. just above the roots), "root growth" to primary growth in length. "Top" refers to the upper end of the stem, while "tip" refers to the upper end of a shoot. "Buds", unless otherwise specified, refers to vegetative buds.

Respiration of the Roots in Relation to Injury

The initial injury to the roots when they were first placed in the containers was quite severe, consequently, the initial higher level of root respiration may be ascribed to the effect of wounding. The literature on the subject of the effect of injury on plant tissue is voluminous. All workers (*2, 4, 5, 8, 10, 12*) are in agreement that wounding greatly increases respiration. In the present experiments the root respiration continued increasing in some cases up to the time of the second determination (determinations were made weekly, before it fell to a lower level. The initial injury was probably more severe in these cases than in others.

Taking the roots from the solutions and placing them in tap water while the original containers were cleaned caused a sharp increase in root respiration the following week and a fall the succeeding week. Unless some other influence was operating which tended to increase root respiration and neutralize the fall as recovery from injury was made, the rate went down to the original level. Whenever a tree was lifted out of the solution for examination, although it was put back in the same solution almost immediately, increased respiration took place. Opening the cans and not lifting the roots clear from the solution, however, apparently had no effect.

Respiration of the Roots in Relation to Activity of the Top.

Relation to buds. The bursting of healthy vegetative buds markedly depressed root respiration, although it increased prior to their bursting. When blossom buds burst, there was an increase in root respiration prior to their bursting but no decrease took place at the time they burst. In the case of the Pear on Japanese tree number 25, when the blossom buds burst no apparent effect was noted but at this time vigorous shoot growth was taking place which apparently masked the effect due to the blossoms.

Relation to shoot growth. After the vegetative buds burst, and coincidently root respiration was at a low level, this low level continued for some time after shoot growth was well under way.

In the normal trees Group I, at a certain stage in new shoot growth when the leaf area was increasing relatively fast, root respiration gradually increased to a maximum which was either coincident with, or a short time before or after, the time shoot growth in length ceased. If no new buds burst and no new shoot growth took place later as in the case of all the trees in this group with the exception of the Apricot on Apricot trees, root respiration remained fairly constant for the remainder of the growing season with only a slight tendency to drop. In the Apricot on Apricot trees during the period from July 2 to August 27, at which time the second and third growth cycles took place, root respiration was very erratic, being more so in trees numbers 4 and 5 where three growth cycles took place than in tree number 6 where only two occurred.

In the Cherry trees, numbers 7, 8 and 9, there was a considerable variation in the root respiration curves of the three trees. In number 7 only a single maximum was reached in September although shoot elongation ceased in early August. In number 8 a first and probably insignificant maximum was reached in August, about the time shoot elongation ceased, which was followed by a much greater maximum in September. In tree number 9 a maximum was reached a little before shoot elongation ceased around July 23 and this maximum was more pronounced than the later level in September.

In the Pear on Quince trees, numbers 22, 23 and 24, shoot elongation ceased approximately at the same time in July although the maximum point in the root respiration curve was reached in June. After this June maximum a fairly constant level was maintained throughout the growing season. In tree number 23, when new buds burst around September 3 and a new shoot grew in length until about October 1, the fall and rise in the root respiration curve around these dates may be significant. A slight similar variation occurred with tree number 24 about September 21, when a few buds burst and started to grow but ceased elongation almost immediately. It should also be mentioned at this point that in the Pear on Quince trees and Pear on Japanese number 24, the branches were distributed from the base of the stem to the upper portion of the stem whereas in the remaining trees branching was from the upper and middle portions of the stem.

In the Pear on Japanese trees, numbers 25 and 26, tree number 25 reached a maximum in the root respiration curve about the time shoot elongation ceased around August 13 but was followed by a greater one in September. Tree number 26 reached a maximum about the time shoot elongation ceased and then remained constant.

In Group II, as in Group I, when normal growth took place root respiration was low during the initial phase of shoot elongation and increased as elongation progressed, and leaf surface increased up to a first maximum which was either coincident with or before, but not after, the time shoot elongation ceased. In the trees of this group after the first maximum was reached a relatively larger and more distinct drop in root respiration took

place than in Group I before a second maximum was reached. These two well defined maxima with a well defined low point between, are significant as they were not always clearly defined in Group I.

The Pear on French trees, numbers 19, 20 and 21, which initially made fairly good shoot growth before the death of the roots, showed an increase in root respiration up to a maximum point around the time shoot elongation stopped, followed by a fall but not by a secondary maximum at this time.

Relation to increase in diameter of stem. It has been stated that in the normal trees Group I, in some cases a drop in root respiration took place after the first maximum was reached (about the time shoot elongation ceased) although this drop in all cases was not clearly defined. At this time increase in diameter of the stem was going on, in some cases slightly faster and in others at about the same rate as before the drop. It has also been stated that in the starved trees Group II, the drop after the first maximum in root respiration was clearly defined and at this time increase in diameter of the stem was taking place relatively rapidly, very little such increase having been made while shoot elongation was taking place. The connection between this drop in root respiration and increase in diameter of the stem seems clear, particularly in Group II.

Respiration of the Roots in Relation to Activity of Root

Relation to primary growth in length (fibres). New root growth started usually before buds burst. Root respiration was low at this time. Even when new primary root growth was rapid before vegetative buds burst, no very significant increase in respiration was noted. During December, January and February, when all other growth had ceased, this new root growth in length was taking place rapidly in a number of trees. A great variation in the amount of root respiration took place at this time.

It may be significant that, particularly within a species, more dense fibrous branched roots appeared to be accompanied by higher respiration than more open and sparsely branched new roots, irrespective of the total weight of new roots produced.

Relation to diameter increase of the root (stub). In the normal trees Group I, it has been mentioned that stem thickening was taking place rapidly about the time the slight depression in root respiration occurred, and that this depression was followed by an increase in root respiration around September. Around September diameter growth of the base of the stem was taking place fairly rapidly and presumably was doing so in the root stub. It was also previously mentioned that the upper portion of the stem ceased thickening before the basal portion with the exception of the Pear on Quince. There seems to be a very definite connection between this secondary September maximum in root respiration and the period at which root thickening is going on after the upper portion of the stem has ceased to thicken. It is a significant fact that no September maximum occurred in the Pear on Quince trees where the upper and basal portion of the stem ceased thickening at approximately the same time.

In the starved trees Group II, the very well defined second maximum in root respiration which occurred at the time base thickening of the stem was taking place relatively rapidly, is very suggestive that a close connection exists between these two phenomena. The Pear on French trees, numbers 19, 20 and 21 are of especial interest at this point—as previously mentioned, about the time initial shoot growth ceased, root respiration fell and no secondary maximum was attained. It has also been noted that while increase in diameter of the upper portion of the stem took place none was recorded at the base and so presumably none took place in the roots. The relationship seems clear.

The picture then presented is: In the starved trees Group II, whenever normal growth occurred, root respiration showed a well defined maximum about the time shoot elongation ceased. This was followed by a distinct depression while increase of the stem was taking place relatively rapidly. Then a well defined maximum took place, as the base of the stem and presumably the root stub continued to increase at the time the upper portion of the stem was either growing relatively slowly or had ceased to grow. With the trees of Group II the sequence was clearly defined and, although results were less definite in the case of the trees of Group I, all the evidence points to a similar behaviour with the members of that group as well.

Discussion

That any activity of the top of the tree greatly influences the respiration of the root is brought out by the experiments, different activities influencing it in opposing directions.

Injury. It was initially unfortunate, but unavoidable, that injury to trees should affect the results obtained, since such injury tended to obscure the effects on root respiration of phenomena that are more important so far as this experiment was concerned. Opinions are divergent as to why injury increases respiration. Cerighelli (*3*), working with herbaceous fibrous roots and perennial fleshy roots, found that the influence of wounds depends on the stored material in the tissue. If reserves are abundant, injury due to wounding increases respiration while, if they are scarce, it decreases respiration. Friedrich (*5*) found that carbohydrates decreased on wounding tissue because it increased respiration. El Sawy (*4*), working with Pear branches, found that with increased respiration an increase of sugar is obtained at the expense of starch.

It appears, then, that the nature and extent of the effect of injury on root respiration in the present experiment could be ascribed to the severity of the injury, the amount of stored food present and a changing of a portion of this stored food to sugar.

The influence of buds on root respiration. The influence of buds on root respiration was pronounced and suggests some interesting speculations. Bergman (*1*) measured the respiration of various parts of the Cranberry plant and found that buds and young shoots were regions of high respiratory activity and leaf buds were regions of much greater respiratory activity than either blossom buds or young shoots. Van der Lek (*13*), working with woody plants, found that the development of leaf buds produces a sub-

stance of the nature of a hormone which stimulates root growth. Hooker (9), working with Apple trees, found that the formation of blossom buds rather than leaf buds is accompanied by a relatively high local accumulation of carbohydrates. It is suggested, then, that the increased root respiration, just prior to the bursting of the buds, was due to a mobilization of respirable material in the roots by some sort of stimulus (hormone) excreted by the developing bud. The decreased root respiration at the time leaf buds burst was due to an immediate local deficit of material occurring in the region of the buds owing to their high respiratory activity. As a result a migration of materials towards the bud took place and the mobilized materials in the root moved up, resulting in a decrease in root respiration.

When blossom buds burst, and the higher level of root respiration attained prior to the bursting of the buds persisted without a decrease, it is suggested that, owing to the fact that blossom buds are regions of lower respiratory activity than leaf buds and are also accompanied by a relatively high local accumulation of carbohydrates, no immediate deficit of materials resulted and the mobilized materials in the root remained and were consumed where they were.

The influence of shoots on root respiration. The influence of shoot growth is another factor having a pronounced influence on root respiration. At the time root respiration began and continued to increase, after maintaining its low level at the time vegetative buds burst and during early shoot growth, the leaf surface was increasing relatively rapidly compared to shoot elongation. This suggests that the increasing leaf surface was manufacturing more materials than were needed for immediate top growth and so increasing supplies of respiratory material were translocated to the root.

The influence of diameter increase of the stem in root respiration. The next stage, where the increasing amount of root respiration reached a point (first maximum) where it remained fairly constant for a time prior to a drop or else dropped suddenly, suggests that in the former case a point of equilibrium was reached where the top was manufacturing and consuming supplies at a fairly uniform rate and a fairly constant supply reached the root, while in the latter case some factor intervened which utilized or cut down supplies going to the root. This factor appears to be secondary growth, namely, diameter increase of the stem, which point is brought out more clearly in the starved trees Group II, than in the normal trees Group I. While little or no increase in diameter of the stem took place as shoot elongation was taking place in the starved trees Group II, it appears that some materials were being contributed from the leaves or growing shoots which increased root respiration. This substance which increased root respiration was cut off about the time shoot elongation ceased. Assuming that it was carbohydrates, it would appear that before diameter growth of the stem will take place to any extent a certain concentration is required. When the shoots were elongating there was not a sufficient concentration to supply this length growth and provide for rapid diameter increases of the stem at the same time. However, as stated, some material did reach the roots. When shoot elongation ceased, all the supplies were then available for diameter growth and little

reached the roots, indicating that more material is necssary for growth in thickness than for growth in length. In the normal trees the large healthy leaf surface was adequate to provide ample materials for all types of growth to proceed without noticeable interference with each other. If, however, the effect of increase in diameter of the stem and branches on root respiration had not been pronounced, it would be expected that root respiration would have increased when shoot elongation stopped. This was not usually the case in the healthy trees. The root respiration curve at this time, then, is a result of two conditions, one tending to increase root respiration due to supplies coming from the top, and one tending to decrease it by utilizing these supplies before they reach the root.

The influence of diameter increase of the root on root respiration. Following the above reasoning, the secondary maximum in root respiration which was attained when the base of the stem was still thickening but had stopped or was very slow in the upper portions, can be attributed to practically all supplies being available for root growth at this time. This seems to be verified in the case of the Pear on Quince trees where increase in diameter of the base of the stem ceased at approximatly the same time as the upper portion and coincidently no secondary maximum of root respiration was reached. Moreover, the increase in thickness of the stem relative to other growth in these trees was large and the height of the root respiration curve is relatively low compared to the other normal trees, with the exception of the Pear on Japanese tree number 26 where a similar situation occurred.

The case of the Pear on French trees, which during their initial growth period made some top growth and secondary increase in the upper portion of the stem, but not in the lower portion, indicates that increased thickening in the top takes place before it occurs in the base of the stem or roots, and that if supplies are then too depleted it does not take place in the lower regions.

In this regard the works of Knight (*11*) and Hatton and Amos (*7*) are of interest. Knight found that when dormant buds break into growth in the spring the new xylem appears first in the regions bearing such developing buds. Thickening of the regions of the stem which do not carry active buds begins only at a later stage, succeeding progressively from the vicinity of the new shoots. The region nearest these shoots, owing to its position, is most favourably situated for obtaining these products and it is the first to begin to expand. Only when the requirements of this portion of the stem are provided, are supplies available for other regions.

The assumption of the relation of the carbohydrates to root respiration seems justified. The further the roots were away from the growing shoots and leaf surface, the longer carbohydrates took to reach them, and the more that was utilized by the tops the less was available for the roots and their respiratory activity; when all was available for the roots a great increase in root respiration occurred.

It seems clear, then, that diameter growth of both root and top pronouncedly influence root respiration and these factors influence it in opposing directions.

The influence of root growth in length (fibres) on root respiration. The influence of the new root growth in length on root respiration seems obscure but must be a decided factor. It has been mentioned that, when initial root growth started, root respiration was low. As at all times a certain amount of such growth was taking place in the healthy trees, its influence was masked by other growth processes for the greater part of the season. During December, January and February, when all other apparent growth activities had ceased, a number of the trees made their greatest root growth in length. At this time root respiration was high in some cases, in others it was low, but in all cases it was lower than the September maximum. When secondary thickening of the root stub accompanies primary root growth it appears that higher respiratory activity takes place than when primary root growth alone is going on, even though this primary root growth alone is more rapid than when accompanied by secondary thickening of the root stub. The fact that primary growth in length can take place rapidly when other growth processes are stopped and that such growth may be accompanied by low CO_2 production, at least suggests that this growth can take place when there are not sufficient mobilized reserves to keep both primary and secondary growth supplied. Furthermore, such a situation may present a parallel case to top growth in the starved trees where shoot elongation took place before secondary increase in the stem, and if sufficient activated respiratory material was not present secondary growth of the stem did not proceed.

Summary

An apparatus for studying tree root respiration was described in a previous paper. This apparatus was used to determine the effects of various phases of top growth and other influencing factors on tree root activity as indicated by measuring the carbon dioxide production of the root.

There appears to be an inherent specific difference in the metabolism of different species of root stocks as determined by their CO_2 production. Some of the variation within a species can be explained by the following factors which influence root respiration:

1. Any injury to the root, often only amounting to a slight disturbance, resulted in a temporary increase in its respiratory activity.

2. The bursting of buds markedly depressed root respiration although it increased prior to their bursting. Vegetative buds had a more pronounced effect than blossom buds.

3. In the early stages of shoot growth respiration of the roots remained at a low level. At a certain stage in shoot growth when the leaf area was increasing relatively fast, root respiration increased rapidly until around the time shoot elongation ceased. When shoot elongation ceased and all the reserves were available for other growth processes, increase in diameter of the stem took place with great rapidity which, however, lowered the root respiration by cutting down supplies to the root. When diameter increase in the stem ceased in the upper portion but was still taking place in the basal portion and roots, all supplies were available for the root, and root respiration increased. Thus diameter growth of the top depressed root respiration while that of the root increased it.

4. New root growth in length continued to take place when all other apparent activities had ceased but was usually accompanied by a relatively low respiratory activity at this time.

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Appendix

Individual tree records and accompanying charts show the weekly CO_2 production of the roots for the duration of the experiment. The weekly mean temperature of the greenhouse in which the experiment was conducted is shown on the charts. The temperature of the solutions in which the trees were grown was kept approximately constant throughout.

TABLE 1.

Individual Tree Records. Group 1. Normal Trees. Apricot on Apricot Root. Trees 4, 5, 6.

Operation causing injury	Buds	Shoot Growth	Diameter increase of stem	Root Activity	Pruning, injections and topping.
TEEE NUMBER 4					
1927 Apr. 17: cleaned cans. May, 5: cleaned cans. June, 10: examined. 1928 June, 8: examined roots.	1927 Apr. 16: buds burst 1928 Mar. 17: blossom buds burst. Mar. 24: in bloom. Mar. 31: leaf buds bursting. Apr. 14: 10 leafy shoots. May, 12: new buds burst.	1927 May 20: 1st cycle shoots growing fast. June, 25: 1st cycle shoot growth stopped. July, 9-23: 2nd cycle shoot growth. Aug. 6—Sept. 3: 3rd cycle shoot growth. 1928 Apr. 7: 5 shoots start. Apr. 21-May 5: shoots growing fast. June 28: shoot growth stopped.	1927 Aug. 27: stem thickening rapid. Sept. 10: base thickening rapid. Sept. 17: top thickening stopped. Oct. 1: base thickening stopped.	1927 Apr. 9: new root growth. Dec. 24— Feb. 26: new root growth light.	1928 Apr. 7: 23 grams pruned from top. May 12: 21 grams pruned from top. June 9: iron injected in top.
TREE NUMBER 5					
1927 Apr. 17: cleaned cans. May 5: cleaned cans. June 10: examined. Oct. 22: examined. 1928 Mar. 17: examined	1927 Apr. 6: buds burst. July 9: " " Aug. 6: " " 1928 Apr. 7: buds swelling at base of stem. May 5: buds burst at base of stem.	1927 Apr. 29: 1st cycle shoots growing fast. June 17: 1st cycle shoot growth stopped. July 9-23: 2nd cycleshoot growth. Aug. 6- Sept. 3: 3rd cycle shoot growth. 1928 May 12- June 9: weak shoots growing.	1927 Sept. 10: base thickening rapid. Sept. 17: top thickening stopped. Oct. 1: base thickening stopped.	1927 Apr. 6: new root growth. Oct. 22: rapid new root growth. Dec. 24- Mar. 17: new root growth light.	1928 Apr.7: 20 grams pruned from top. June 16: topped.
TREE NUMBER 6					
1927 Apr. 16: cleaned cans. May 20: ditto. June 17: examined. 1928 May 17: examined.	1927 Apr. 16: buds burst July 23: " " 1928 Mar. 24: " " Apr. 7: " " May 12: " "	1927 May 6: rapid shoot growth. June 25: 1st cycle shoot growth stopped. July 23-Aug. 20: 2nd cycle shoot growth. 1928	1927 July 9: rapid stem thickening. Aug. 27: top thickening stopped. Sept. 3: base thickening rapid. Oct. 22: base thickening	1927 Apr. 9: new root growth. Oct. 15: new root growth. Dec. 24- Apr. 9: new root growth light.	1928 Apr. 7: 20 grams pruned from top. June 16: topped.

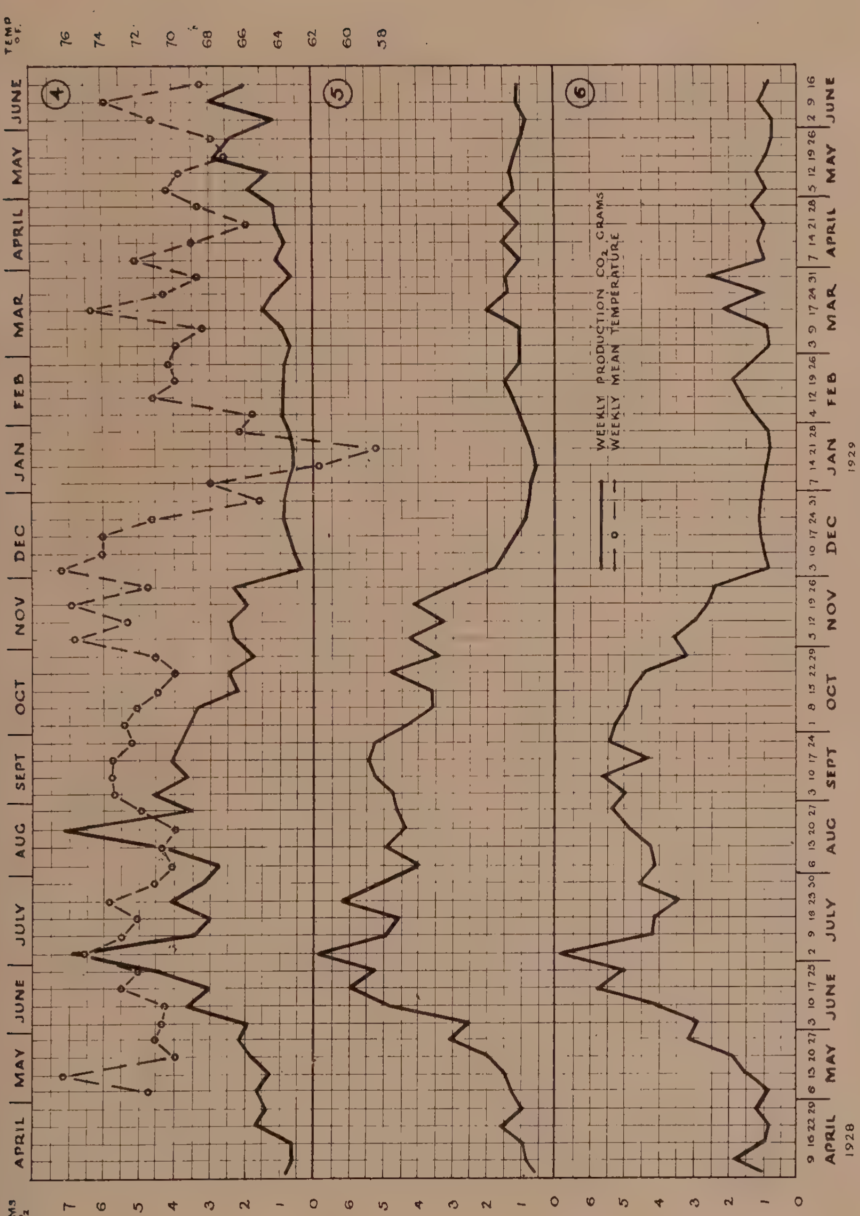

CHART I.– GROUP I. NORMAL TREES. APRICOT ON APRICOT. NOS. 4, 5, 6.

TABLE 2.

Individual Tree Records. Group I. Normal Trees. Bing Cherry on Mazzard Root. Trees 7,8,9.

Operation causing injury	Buds	Shoot Growth	Diameter increase of stem	Root Activity	Pruning, injections, topping and ringing
TREE NUMBER 7					
1927 Apr. 17: cleaned cans. May 20: cleaned cans.	1927 Apr. 29: buds burst. 1928 Feb. 26: buds burst, but dried up. June 2: buds burst June 9: 5 leafy shoots.	1927 May 20- July 16: shoot growth rapid. July 23- Aug. 13: shoot growth slow. Aug. 20: shoot growth stopped. (large leaf area) 1928 June 23: many leaves—no new shoots.	1927 Aug. 27- Oct. 1: base thickening rapid. Sept. 10: top thickening stopped. Oct. 8: base thickening stopped.	1927 Apr. 9: new root growth. Dec. 31- Feb. 26: new root growth rapid.	1928 Apr. 7: 4 grams pruned from top. May 5: 25 grams pruned from top. May 23: injected sugar.
TREE NUMBER 8					
1927 Apr. 16: cleaned cans. May 5: cleaned cans. 1928 Mar. 17: examined. June 8: examined.	1927 Apr. 29: buds burst. June 17: " " 1928 Feb. 26: buds burst but dried up. June 2: buds burst.	1927 May 6- June 10: weak shoot growth. June 17- July 30: vigorous shoot growth. Aug. 6: shoot growth stopped. 1928 June 23: many leaves but no new shoots.	1927 Sept. 10: top thickening stopped. Sept. 17 Oct. 1: base thickening rapid. Oct. 8: base thickening stopped.	1927 Apr. 9: new root growth. Dec. 31- Mar. . . :new root growth rapid.	1928 Apr. 7: 5 grams pruned from top. May 5: 60 grams pruned from top. May 24: injected sugar.
TREE NUMBER 9					
1927 Apr. 16: cleaned cans. May 5: cleaned cans. 1928 Feb. 4: examined. Mar. 17: examined. June 8: examined.	1927 Apr. 29: buds burst. 1928 June 9: buds burst.	1927 May 20- July 9: shoot growth rapid. July 23: shoot growth stopped. 1928 June 30- July 14: shoots growing fast. July 31: shoot growth	1927 July 16: base thickening rapid. Aug. 27: big increase middle of stem. Sept. 24: top thickening stopped. Oct. 15: base thickening stopped.	1927 Apr. 9: new root growth. Sept. 17: new roots growing rapidly. Dec. 3- Mar. new root growth rapid.	1928 Apr. 7: 10 grams pruned from top. May 5: 8 grams pruned from top. June 26: ringed at base.

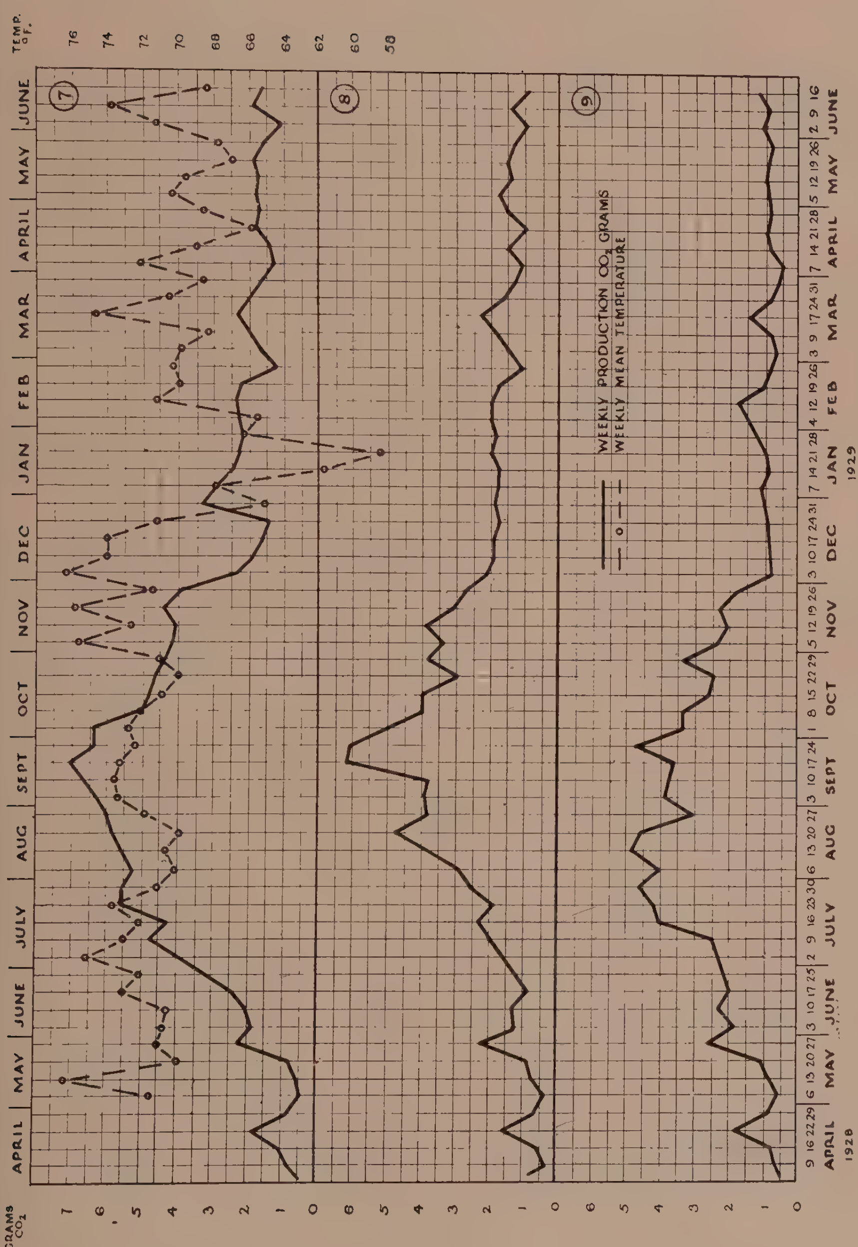

CHART II.—GROUP I. NORMAL TREES. BING CHERRY ON MAZZARD. NOS. 7, 8, 9.

TABLE 3.

Individual Tree Records. Group I. Normal Trees. Hardy Pear on Quince Root. Trees 22, 23, 24.

Operation causing injury	Buds	Shoot Growth	Diameter increase of stem	Root Activity	Topping, pruning, injections.
		TREE NUMBER 22			
1927 Apr. 16: cleaned cans. May 20: cleaned cans. June 10: cleaned cans. Aug. 27: examined. Nov. 5: examined 1928 Mar. 17: examined.	1927 Apr. 29: buds burst. 1928 June 2: buds burst.	1927 May 20: good shoot growth July 2: shoot growth stopped. 1928 June 16: 12 spindly leafy shoots.	1927 July 9- Oct. 29: stem thickening uniformly. Nov. 5: stem thickening stopped	1927 Apr. 16: new root growth. May 20: good root growth Aug. 27: good root growth Nov. 5- Mar. : rapid root growth.	1928 Apr. 7: 5 grams pruned from top. May 5: 5 grams pruned from top. May 20: injected sugar. June 16: topped.
		TREE NUMBER 23			
1927 Apr. 16: cleaned cans. May 5: cleaned cans. June 10: cleaned cans. Aug. 27: examined. 1928 Mar. 17: examined.	1927 Apr. 29: buds burst. Sept. 3: new buds burst. 1928 June 2: small buds burst.	1927 May 20: good shoot growth. July 30: shoot growth stopped. Sept. 10- Oct. 1: new shoot growth. 1928 June 16: 9 leafy shoots.	1927 Aug. 6- Nov. 5: stem thickening uniformly. Nov. 12: stem thickening stopped.	1927 Apr. 16: new root growth. May 20: good root growth. Aug. 27: good root growth. Nov. 5- Mar. : rapid root growth.	1928 May 5: 40 grams pruned from top. May 21: injected sugar. June 16: topped.
		TREE NUMBER 24			
1927 Apr. 16: cleaned cans. May 20: cleaned cans. July 16: examined. Aug. 20: examined. Oct. 1: examined. Nov. 19: examined 1928 Mar. 17: examined.	1927 Apr. 6: buds burst. Spet. 3: new buds burst. 1928 June 2: buds burst. June 9: 9 buds burst.	1927 May 20: good shoot growth. July 23: shoot growth stopped. Sept. 10-17: slight shoot growth. 1928 June 6- July 7: spindly shoot growth	1927 July 30- Oct. 1: stem thickening uniformly. Oct. 8- Oct. 29: stem thickening very slow. Nov. 5: stem tihckening stopped.	1927 Apr. 16: new root growth. May 20: good root growth. July 16: good root growth. Aug. 20: good root growth. Nov. 19- Mar. : rapid root growth.	1928 May 5: 23 grams pruned from top. May 22: injected sugar.

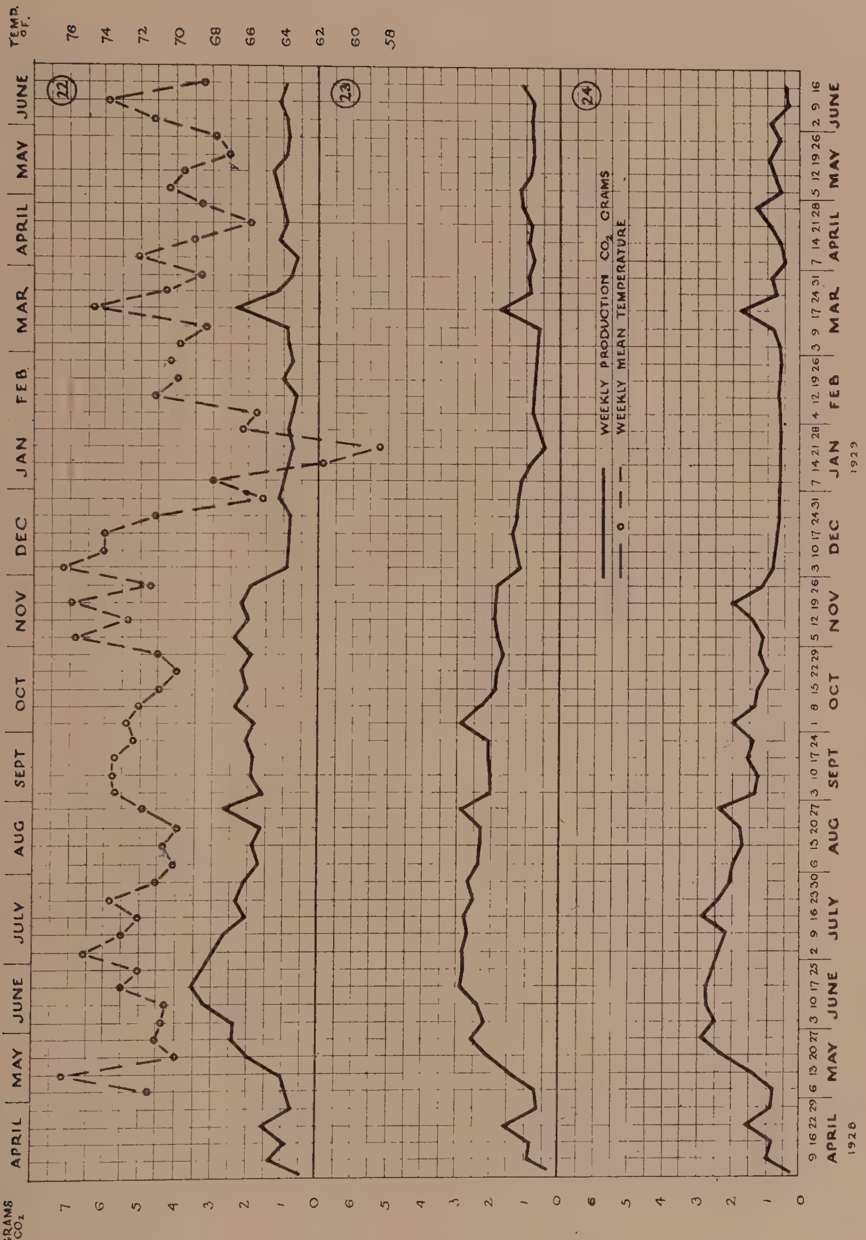

CHART III.—GROUP I. NORMAL TREES HARDY PEAR ON QUINCE. NOS. 22, 23, 24.

TABLE 4.

Individual Tree Records. Group 1. Normal Trees. Bartlett Pear on Japanese Root. Trees 25, 26.

Operation causing injury	Buds	Shoot Growth	Diameter increase of stem	Root Activity	Pruning, injections, ringing.
TREE NUMBER 25					
1927 Apr. 16: cleaned cans. May 5: cleaned cans. June 10: examined. Sept. 17: examined. 1928 Mar. 17: examined.	1927 Apr. 6: buds burst. Apr. 29 " " 1928 May 19: " " July 7: blossom buds.	1927 Apr. 9- Aug. 13: shoot growth. July 16- Aug. 6: shoot growth very rapid. 1928 May 19: shoot growth	1927 Sept. 3: upper portion stem thickening fast. Sept. 24: top thickening stopped. Sept. 10: base thickening rapid. Oct. 15: base thickening stopped	1927 Apr. 16: new root growth. May 20: good root growth. Sept. 17: good root growth. Dec. 24- Mar. : new root growth light.	1928 Apr. 29: injected sugar. May 5: 80 grams pruned from top. May 23: injected sugar
TREE NUMBER 26					
1927 Apr. 17: cleaned cans. May 5: cleaned cans. Oct. 1: cleaned cans. 1928 Mar. 17: cleaned cans.	1927 Apr. 6: buds burst. Apr. 29: more buds burst. 1928 May 19: buds burst. June 2: buds burst.	1927 Apr. 29- Aug. 13: shoot growth. July 16- July 30: shoot growth rapid. 1928 July 9- July 21: shoot growth.	1927 June 17- Oct. 22: stem thickening uniformly. Oct. 22: stem thickening stopped.	1927 Apr. 16: new root growth rapid. May 20: good root growth. Oct. 1: good root growth. Dec. 3- Mar. : new root growth light.	1928 Apr. 14: 1 gram pruned from top. May 12: 8 grams pruned from top. June 18: ringed.

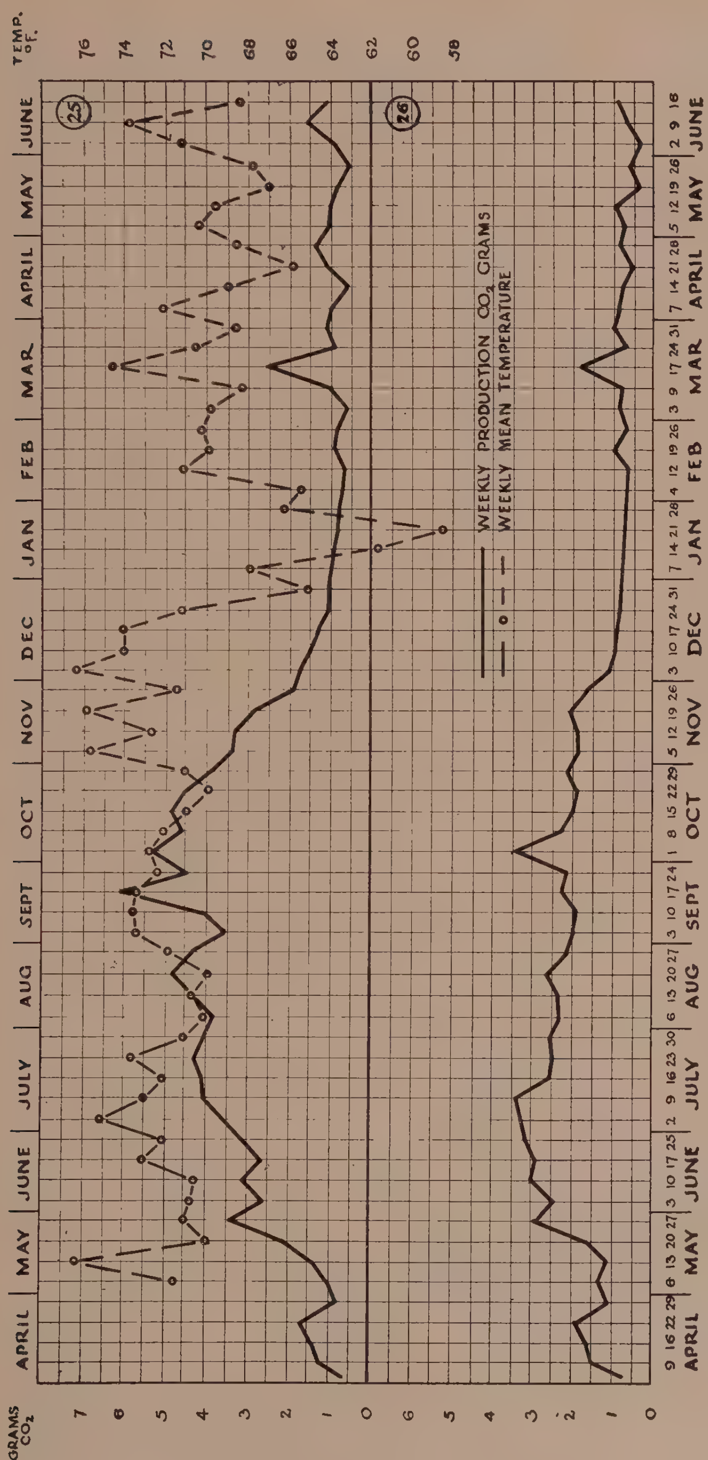

CHART IV.—GROUP I. NORMAL TREES. BARTLETT PEAR ON JAP. NOS. 25, 26.

TABLE 5.

Individual Tree Records. Group II. Starved Trees. Apricot on Myrobalan Root. Trees 1, 2, 3.

Operation Causing injury	Buds	Shoot Growth	Diameter increase of stem	Root Activity	Pruning, injections, topping
TREE NUMBER 1					
1927 Apr. 17: cleaned cans. May 20: cleaned cans. June 17: cleaned cans, and raised level of solution.	1927 May 13: buds burst. July 30: new buds burst 1928 Mar. 17: new buds burst. May 26: new buds burst.	1927 May 20: shoots not healthy. Aug. 13- Oct. 8: healthy shoot growth. 1928 Mar. 24- May 12: good shoot growth. July 2: new shoot growth.	1927 Oct. 15: stem thickening Nov. 5- Dec. 24: base thickening. Nov. 5- Dec. 10: base thickening fast.	1927 Apr. 17: new root growth. May 20: roots not healthy. June 17: roots not healthy. July 16: new roots. Dec. 31- Mar.: root growth rapid.	1928 Apr. 7: 4 grams pruned from top. May 7: heavy injection of iron killed most leaves. June 20: topped.
TREE NUMBER 2					
1927 Apr. 16: cleaned cans. May 20: cleaned cans. June 17: cleaned cans and raised level of solution. July 23: examined.	1927 May 13: buds burst. Sept. 3: buds burst. Nov. 26: buds burst. 1928 Mar. 24: buds burst. June 23: new buds on tips	1927 May 20: shoots not healthy. Sept. 10- Nov. 5: healthy shoot growth. Oct. 1: shoot growth slow. Oct. 22- Oct. 29: shoot growth rapid. Nov. 26- Dec. 10: new shoot growth. 1928 Apr. 14- June 2: new shoot growth	1927 Oct. 8: top thickening fast. Nov. 12: base thickening fast. Dec. 14: base thickening	1927 Apr. 29: no new root growth. May 20: new roots not healthy. July 23: new roots dead. Dec. 24- Mar.: new root growth rapid.	1928 Apr. 17: 4 grams pruned from top. June 26: topped.
TREE NUMBER 3					
1927 Apr. 16: cleaned cans. May 20: cleaned cans. June 19: cleaned cans. July 16: examined. Nov. 12: examined.	1927 May 6: buds burst. Aug. 27: buds burst. Oct. 15: buds burst. 1928 May 12: buds burst. June 9: buds burst	1927 May 20: shoots not healthy. June 3: shoot growth stopped. Sept. 3- Sept. 24: light shoot growth. Oct. 22- Dec. 10: light shoot	1927 June 17: stem thickening. Oct. 8: stem thickening. Dec. 17: top thickening only. Dec. 24: top thickening stopped.	1927 Apr. 29: some new root growth. June 19: new roots dead. July 23: new root growth. Nov. 12: new roots healthy. Dec. 31: new root growth light. 1928	1928 Apr. 7: 3 grams pruned from top.

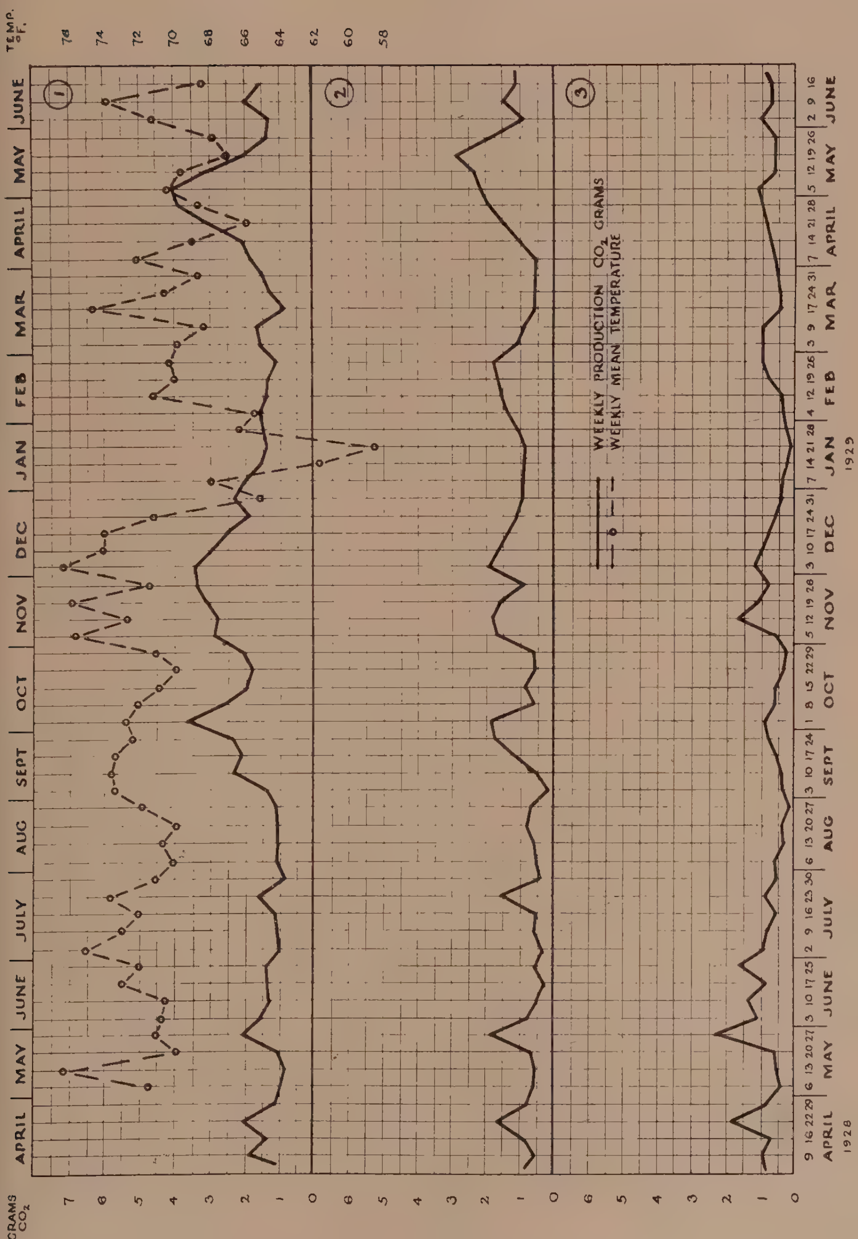

CHART V.- GROUP II. STARVED TREES. APRICOT ON MYROBOLAN. NOS. 1, 2, 3.

TABLE 6.

Individual Tree Records. Group II. Weak Trees. Bartlett Pear on French Root. Trees 19, 20, 21.

Operation Causing injury	Buds	Shoot Growth	Diameter increase of stem	Root Activity	Pruning, topping, etc.
TREE NUMBER 19					
1927 Apr. 16: cleaned cans. May 20: cleaned cans. June 10: cleaned cans, and put in distilled water.	1927 Apr. 16: buds burst. 1928 Mar. 24: buds burst.	1927 Apr. 22- June 3: shoot growth. 1928 Apr. 7- May 5: shoot growth.	1927 June 25: top thickening only.	1927 Apr. 16: new root growth. May 20: healthy new root growth. July 16: roots unhealthy. Nov. 12: small amount new root growth. 1928 Jan. 7- Mar.: new root growth rapid.	1928 June 16: topped.
TREE NUMBER 20					
1927 Apr. 16: cleaned cans. May 20: cleaned cans. June 10: cleaned cans, and put in distilled water	1927 Apr. 29: buds burst. Aug. 27: buds burst. Oct. 8: buds burst. 1928 Apr. 28: buds burst. May 12: buds burst.	1927 May 6- June 3: weak shoot growth. Sept. 3- Nov. 19: shoot growth. 1928 May 6- June 16: leaf clusters only formed.	1927 Nov. 26: stem thickening Dec. 24: stem thickening stopped.	1927 Apr. 16: new root growth. June 10: healthy new root growth. July 16: new roots dead. Sept. 17: new root growth. 1928 Jan. 7- Mar.: new root growth rapid.	1928 Apr. 7: 20 grams pruned from top. June 16: topped.
TREE NUMBER 21					
1927 May 20: cleaned cans. June 11: cleaned cans, and put in distilled water. Oct. 1: examined. Nov. 12: cleaned cans.	1927 May 6: buds burst. 1928 Feb. 12: buds burst.	1927 May 13- June 10: shoot growth. 1928 Feb. 19- May 5: shoot growth.		1927 Apr. 22: new root growth. June 10: good root growth. July 16: new roots dead. Sept. 24: new root growth. Dec. 17: new root growth light. 1928	1928 Apr. 7: 20 grams pruned from top. June 16: topped.

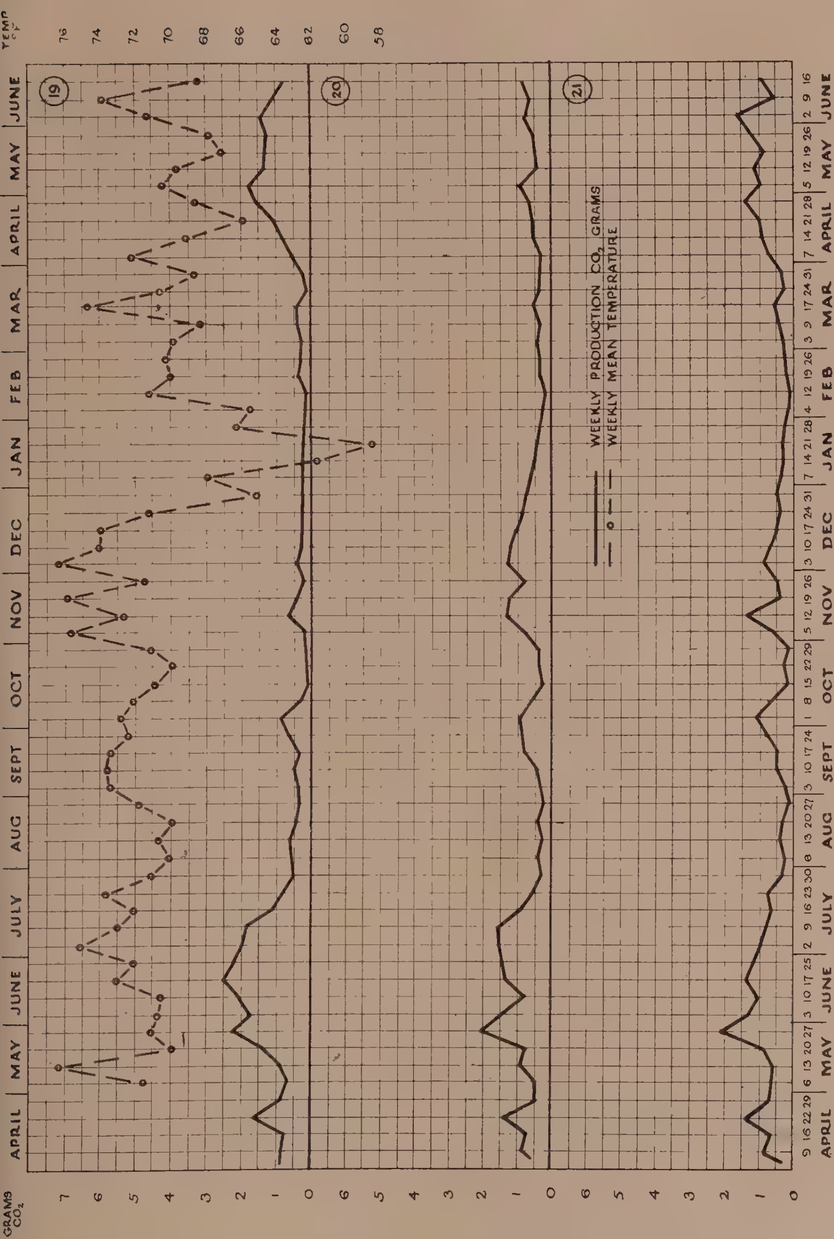

CHART XI.—GROUP II. STARVED TREES. BARTLETT PEAR ON FRENCH. NOS. 19, 20, 21.

MARKET REQUIREMENTS AND THE CANADIAN GRADES OF BARLEY *

T. J. Harrison †
Board of Grain Commissioners for Canada, Winnipeg, Man.

The market requirements of barley vary with the different uses to which it is put and often for the same use in different countries. There are many different types and qualities required, for barley has more uses than any other grain crop.

Uses of Barley

Most of the uses may be grouped into the three following categories (1) human food, (2) human beverages and (3) live stock feed.

(1) HUMAN FOOD

In the preparation of barley for food it may either be milled or malted.

The milling of barley consists in removing the hull by rolling the kernels between two rough surfaces set sufficient distance apart to prevent crushing the grain. Before this operation can be successfully carried out the grain must be dry, preferably not more than 10 per cent moisture. After the hull has been removed it is prepared in different ways depending on how it is to be used.

(a) *Pot and pearl barley*:—Pot barley is the barley with the hull taken off but the underskin not completely removed. It, therefore, has a mottled appearance. In some countries this is in demand for use in the preparation of soups. In the manufacture of pearl barley the rolling process is continued, with the roughened surfaces set closer together to remove the underskins of the barley. The product instead of being in the form of oblong kernels is reduced to spheres and is usually pearly white in appearance. Pearl barley is also used in soups but the smaller sizes may be used in puddings.

(b) *Barley meal.* After the hulls have been removed the barley is steamed and rolled, the process being similar to that followed in the preparation of rolled oats. The barley meal or rolled barley is used as a breakfast cereal.

(c) *Barley flour.* This product is made by reducing the hulled barley to the consistency of flour by means of reducing rolls and bolting cloth. The flour is used in the preparation of most of the invalid and baby foods. It is also used as a substitute for part of the wheat flour in baking, and was used somewhat extensively in some countries during the war period.

In the preparation of malted food the barley is soaked, sprouted and dried. The sprouting breaks down the food reserves in the kernel to simpler chemical compounds. Different flavours are obtained by drying at different temperatures. The hull is then removed by milling and the malt prepared in different ways.

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†Assistant Grain Commissioner, formerly Professor of Agronomy, Manitoba Agricultural College, Winnipeg, Man.

(a) *Breakfast foods.* Most of the prepared breakfast foods either contain malt as the base of the food or as the flavouring ingredient. It makes the food not only very palatable but most nutritious because it is usually high in enzymes and vitamins.

(b) *Malt food.* The malt food products are legion in number. The ground hulled malt is used as the base and the product is flavoured with cocoa, etc. Such substances as malted milk, toddy, vitone, ovaltine, bermaline and veda are good examples of these products.

(c) *Malt coffee.* This product is made by malting the barley in the ordinary way but it is dried at a high temperature which roasts the malt. The malt thus dried may be ground as ordinary coffee. This is the method employed in Germany where 16,000,000 bushels of barley are used annually for this purpose. In Canada it is usually blended with coffee and chicory. In the latter method it has an odour and flavour very similar to coffee. It is used mainly by people who cannot drink coffee because of the effect of the caffeine.

(d) *Malt flour.* This is prepared by drying the malt at low temperatures, removing the hull and reducing to flour. It is used largely by wheat flour millers who mix a small quantity of it with the wheat flour to induce better gas production in the dough when the bread is being baked.

(e) *Malt extract.* Malt extract is prepared by grinding the malt and extracting the soluble constituents by steam and hot water. The extract is then usually concentrated to the consistency of syrup. In the form of malt syrup it is used extensively in baking, for its sweetening, flavouring, and nutritious value. It possesses considerable medicinal value when mixed with castor oil, iron compounds, hypophosphates, and is also used in laundries and textile factories for destarching cloth.

(f) *Vinegar.* The malt is extracted and the extract fermented into vinegar. It may be a separate industry or a by-product of the distilling industry.

(g) *Malt sugar.* The malt extract is concentrated to a solid and is used as a confection or candy.

(2) HUMAN BEVERAGES

In countries in the northern areas where grapes are not grown barley is the source of both alcoholic and non-alcoholic beverages.

(a) *Fermented Beverages.* In the manufacture of this group of beverages the malt is extracted, and the extract boiled with hops for flavour, yeast is then added to the wort and fermentation takes place.

In the non-alcoholic beverages the alcohol is then distilled off with most elaborate stills to retain the flavour of the fermented wort. The drinks made in this manner are legion such as temperance beers, two per cent, etc.

Alcoholic beverages are made in the same manner except that the alcohol is retained. By varying the kind of barley used, the method of malting, and the kind of fermentation, many different beverages are produced such as lager beer, pale ales, mild running ales, barley wine, stout, etc.

(b) *Distilled Beverages.* The distilled beverages are of two genera classes, malt whiskey and grain whiskey. In the former class the barley is malted, extracted, fermented without hops and distilled. In the latter some of the barley is malted, the malt is mixed with barley, rye, corn, wheat and oats. The diastase in the malt converts the starch to sugar in the other grains, and the extract of the lot is then fermented and distilled.

(c) *Yeast Manufacture.* The manufacture of yeast is a very important side line of the distilling industry although it may be carried on as a separate industry. The extract of the malt is used as the medium on which the yeast is grown. Large amounts of yeast are used in bake shops, breweries and as a food.

(d) *Industrial Alcohol.* With the greater demand for alcoholic solvents in the lacquer and other industries the demand for industrial alcohol is increasing. This product is made from the cheapest sugar or starch that can be purchased. When starch is used barley malt is used as the conversion agent. For example in Northern Germany both barley and potatoes are grown in large quantities. The green barley malt is ground up with the potatoes. The diastase in the malt converts the starch in the potatoes to sugar. The sugar is fermented and distilled and made into industrial alcohol. In some countries where barley is cheap it can be used as the source of the starch also.

(3) LIVE STOCK FEED

While large quantities of barley are used in the industries, the greater portion is used as feed for live stock.

(a) *Feed for Cattle, Sheep and Horses.* Barley may be used as feed for al classes of live stock; but for cattle, sheep and horses it is only used in limited quantities in areas where it is distinctly cheaper than corn and oats. In fact in many of the stock feeding areas in Great Britain and on the Continent it is thought that cattle can only be properly fed on corn even when barley is cheaper. This is also true to a lesser degree even in Eastern Canada. If the market for barley is to be extended to this field it will be necessary to organize considerable educational work in the form of feeding demonstrations.

(b) *Feed for pigs.* As feed for pigs, however, barley is in a class by itself In all of the good bacon districts barley is essential for finishing the product It makes bacon with a firmer, whiter fat than corn or most other feeds. It is in demand in Denmark, Northern Ireland, England and Northwestern Germany.

MARKETS

The market for Canadian barley is confined to the following six countries Great Britain and Northern Ireland, Denmark, Holland, Belgium, Germany and Switzerland. According to calculations made from Broomhalls' estimates these six countries import 98 per cent of all the barley exported from al sources. It is interesting to note that these countries are also large producers of barley. In most cases they produce a much better class of barley than that imported. In this respect the markets for barley and wheat are fundamentally different. The latter is a "buyers' market", while the former is a

"sellers' market". It, therefore, is essential that Canada supply barley suited to the market requirements if she is going to extend, or even maintain, her present markets. Since the requirements are different for the different industries and often for the same industry in different countries, the problem of supplying the demands becomes much more complicated.

Market Requirements in Great Britain

In Great Britain barley is used in the manufacture of bacon, pot and pearl barley, malt food, malt extract, yeast, vinegar, spirits and beer. For these purposes about 90,000,000 bushels are consumed, of which about 40,-000,000 are imported. It has been estimated that Canada exports to this market from 5,000,000 to 20,000,000 bushels. The difference in this last estimate is probably due to the fact that the lower estimate is the exports from Canadian ports only, and the latter the total exports, as the larger amount of Canadian barley goes out by American ports.

In any event, Great Britain is a market well worth preserving, and according to the total imports is capable of further development.

Feed Barley

In Great Britain about 75 per cent of the Canadian barley imported is used in the feeding industry. It is sold to the feeders in three different ways, (a) as barley to the farmer, who grinds and mixes the meal himself, although very little is handled in this way, (b) to private mills or farmers' coöperative trading societies and ground and delivered as meal to the farmer and (c) to compounders who grind the barley and mix it with other meals into compound feeds.

In whatever way it is handled it is used almost exclusively for finishing bacon hogs, where it is essential to the production of a white, firm fat. It might be used to replace corn in other feeds, but the price is usually too high and the quality too low. The foreign competitors of Canada for this market are given by Blood Homan & Co. in the following table, along with the two old feed grades of Canadian barley:—

Country	How Sold	Price Ex Store Bristol. Mar. 20/29
		Cents
Persian	F.A.Q. with 4 per cent dirt clause	90
Algerian	4 per cent admixture clause	86
Tunisian	4 per cent admixture clause	86
Argentinian	Guaranteed natural weight	97
Danubian	3 per cent analysis clause	97
Californian	No. 1 bright feed standard	89
Federal No. 2 U.S.A.	Certificate final	86
No. 4 Canada Western	Certificate final	92
Western Canada Feed	Certificate final	89

If the feed market is to be extended, Canada must either compete with the higher quality and higher priced Danubian and Plate barley, or the cheaper Mediterranean and American barley. It is obvious that the former will be

the most remunerative. To compete in this class the quality must be improved. The requirements of a good feed barley are summarized as follows:—

(a) *Free from impurities.* (Wild oats and other weed seeds). The black hulls of the wild oats are too conspicuous in the meal and the black seeds give the meal a peculiar ordour, both of which are very objectionable.

(b) *Thin in the hull.* Thick hulls do not grind properly and give the meal a fluffy appearance.

(c) *Low in moisture.* (11 to 12 per cent). So that water may be added when blending.

(d) *Bright and "sunny".* This is claimed to indicate that the grain is high in vitamins.

The main objection to Canadian barley is that it contains too many wild oats and weed seeds. Farmers stated that they did not want barley meal which might contain up to 18 per cent wild oats. Merchants stated that the restrictions of the British Fertilizer and Feeding Stuffs Act, made it impossible for them to handle profitably Canadian barley, because of such a high percentage of wild oats and weed seeds.

If this market is to be extended or even maintained; a better quality of barley will have to be offered. This means the production of barleys, thin in the hull, low in crude fibre, high in protein and vitamins, of uniform appearance, bright in colour, and with little or no harvest and threshing damage. It must be delivered containing not more than 5 per cent to 6 per cent wild oats and practically no black seeds.

Canadian Grade for the British Feed Trade

On the recommendation of the National Barley Committee and the Canadian Wheat Pool, the No. 3 C.W. barley definition was amended with the purpose of segregating barley for this market. This definition now reads: "No. 3 Canada Western Barley shall be barley composed of any type or variety, or combination of varieties or types, shall be sweet, reasonably clean, and reasonably free from other grains, may include weather-stained, immature, shrunken, slightly frosted and otherwise damaged barley, and shall not weigh less than 47 pounds to the bushel". The regulations of the Inspection Department governing the impurities in this grade state that No. 3 C.W. barley may contain 6 per cent of other domestic grain, wild oats and seeds, singly or in combination, seeds not to exceed 1½ per cent. Discussions with feeders, millers and compounders indicated that this would be a grade well-suited to their demands.

Pot and Pearl Barley

In Great Britain, the pot and pearl barley and the allied trades of rolled barley, barley flour, etc., now only use about 1,000,000 bushels per year. In the past, this trade was much larger, and was supplied almost exclusively by Canadian barley. Since the British Government passed a regulation prohibiting the sulphur bleaching of these products, Canadian barley (because of the blue aluerone in the Manchuria type) cannot be used. The result is that Canada has lost this trade.

To compete in this trade, a barley must meet the following requirements, (a) A white aluerone, found principally in the two-rowed types, the varieties grown in Western Canada being Hannchen and Duckbill and (b) it must be dry, sweet and contain not more than 11 to 12 per cent moisture.

To supply this trade, a barley that will not stain yellow with the dews or rain is most desirable. Farmers in areas adapted to this type of barley should specialize in its production and to obviate mixing, grow nothing else. At the present time Manchurian, Hannchen and Duckbill would seem to be best suited for this purpose.

Grades for Pot and Pearl Barley Manufacturers

Since the six-rowed barleys produced in Western Canada have a blue aluerone, and the two-rowed barleys have white, it was decided to endeavour to provide grades for the two barleys that would suit this trade. These grades are defined as follows:—

> No. 1. Canada Western Two-Row Barley shall be composed of 95 per cent two-row barley of one variety or type and equal in value for malting or pearling purposes to Canadian Thorpe. It shall be sound, clean, practically free from other grain, plump, bright, and shall weigh not less than 52 pounds to the bushel.
>
> No. 2 Canada Western Two-Row Barley shall be composed of 95 per cent two-row barley of one variety or type and equal in value for malting or pearling purposes to Canadian Thorpe. It shall be sound, reasonably clean, reasonably free from other grains, but not plump or bright enough to be graded No. 1, and shall weigh not less than 50 pounds to the bushel.
>
> No. 3 Extra Canada Western Two-Row Barley shall be composed of 90 per cent two-row barley equal in value for malting or pearling purposes to Canadian Thorpe. It shall be sound, reasonably clean, reasonably free from other grains, but may include weather-stained and slightly shrunken barley and shall weigh not less than 48 pounds to the bushel.

The impurities allowed in these grades are:

No. 1 Canada Western Two-Row. Free from seeds, wild oats and other grains.

No. 2 Canada Western Two-Row. One-half per cent seeds and wild oats, 1 per cent other grains.

No. 3 Extra Canada Western Two-Row. One-half per cent seeds or wild oats, 2 per cent other grains.

Malt Extract

In the United Kingdom, the malt extract and malt food trade is expanding. It has been estimated that it uses about 2,000,000 bushels of barley per year, but when one observes the number of malt houses making this class of malt, one realizes that this estimate must be low.

It was gratifying to find that Canadian barley, because of its high diastatic power, was admirably suited for this trade. There were however, some

very serious objections to it, (1) it contains too many weed seeds, wild oats and other grain, (2) the germination is uncertain and (3) the kernels were often broken and usually badly skinned.

To supply this market, the O.A.C. 21 type, beause of its high diastatic power, should be supplied. Since the market prefers the blue aleurone, because this barley is associated, at least in the minds of the buyers, with the desirable qualities for this trade, only the O.A.C. 21 and Chinese varieties should be grown.

Grades for the Malt Extract Trade

The National Barley Committee and the Committee of the Canadian Pool having in mind the requirements of the malt extract and allied trades, recommended the definitions for six-row barley grades as follows:—

> No. 1 Canada Western Six-Row Barley shall be composed of 95 per cent six-row barley of one variety or type and equal in value for malting purposes to O.A.C. 21. It shall be sound, clean, practically free from other grains, plump, bright and weigh not less than 50 pounds to the bushel.

> No. 2 Canada Western Six-row Barley shall be composed of 95 per cent six-row barley of one variety or type and equal in value for malting purposes to O.A.C. 21. It shall be sound, reasonably clean, reasonably free from other grains, but not plump or bright enough to be graded No. 1, and shall weigh not less than 49 pounds to the bushel.

> No. 3 Extra Canada Western Six-row Barley shall be composed of 90 per cent six-row barley equal in value for malting purposes to O.A.C. 21. It shall be sound, reasonably clean, reasonably free from other grains, but may include weather stained and slightly shrunken barley and shall weigh not less than 48 pounds to the bushel.

The impurities allowed in these grades are the same as outlined for the No. 1, No. 2 and No. 3 Extra Canada Western Two-row Barleys.

Distilling Barley

In Scotland the distilling trade, including the manufacture of spirits, alcohol, yeast and vinegar uses about 5,000,000 to 6,000,000 bushels of barley per year. In this industry there are two classes of barley required, namely that for malt distilling and that for grain distilling.

1. *Malt distilling.* For malt distilling, Scottish, Danish and Australian two rowed barleys, Californian, Danubian, and Indian six-rowed barleys are used. Some Canadian barley was used prior to 1921 but the quality was not equal to these other barleys and was therefore discontinued. For this purpose the barley must be at least 95 per cent high in germination and high in starch content. High protein is not a consideration, excepting in so far as it displaces starch. Discoloured grains are not objectionable, if the grain has not been injured by weathering. High diastatic power is not required as there is usually sufficient diastase in all the barleys used to convert their own starch. The Canadian barleys that might be used to compete in this trade would be O.A.C. 21, Hannchen and Duckbill.

Grades for malt distilling. In malt distilling, No. 3 Extra Canada Western Two-row and No. 3 Extra Canada Western Six-row, as outlined for malt extract and pot and pearl barley, would be suitable. To suit this trade these grades should be even cleaner than the regulations require because practically all the plants used in this industry have no cleaning machinery.

2. *Grain distilling.* For the malt used in grain distilling a barley is required with good germination and high diastatic power. This latter is very essential, for the diastase in the malt is used to convert the starch in the unmalted grain. Prior to the 1926 crop, No. 3 Canada Western was used almost exclusively for this trade. This amounted to about 2,500,000 bushels. Since then no Canadian barley has been used because that year the germination was often not higher than 60 per cent. This was probably due to the placing of artificially dried grain in the No. 3 Canada Western. The result is that Canada has lost this trade to Roumania. The Roumanian or Danubian barleys are uniform in size of kernel, weigh from 51 pounds to 56 pounds per bushel, are absolutely clean and are placed on the market in an excellent condition.

Grades for grain distilling. In this trade grain that will germinate is required. For this reason the word "sound" in the barley grades is defined as follows:— "Sound, shall mean free from frosted, sprouted, heated, musted or artificially dried grain, and shall be practically free from broken, skinned or otherwise damaged grain". Since it is the above injuries that cause low germination, grain that is guaranteed free from them should give high germination. No. 2 and No. 3 Extra Canada Western Six-row are the grades that will suit this trade.

Brewing Barley

In Great Britain, brewing constitutes one of the most important parts of the barley trade. In this industry, wide ranges in prices are obtained. A range of 80 cents per bushel is possible, and 40 cents per bushel is common. Both two-rowed and six-rowed barleys are used.

1. *Two-rowed brewing barley.* The two-rowed types constitute from 60 per cent to 85 per cent of the trade. The eastern counties of England, Czecho-Slovakia, and a small area around San Antonio, Chili, supply the best quality and secure the fancy prices, while Australia, Scotland, Ireland, Denmark, Poland and the Central and Northern counties of England supply an abundance of an inferior quality and secure a price often little better than feed.

A barley to compete in this class must be:—

(a) Low in protein. From 6 per cent to 9 per cent oven dried weight. Most Canadian barleys contain from 9 per cent to 13 per cent.

(b) Mellow or starchy. Canadian barley is hard and steely.

(c) High in germination. 95 per cent to 100 per cent.

(d) Bright and of a uniform straw colour.

(e) Mature with fine transverse wrinkles.

Canada will not be able to compete successfully in this trade, because the climate and soil are not such that the high quality can be produced.

Grades for the two-rowed barley brewing trade. If No. 1 Canada Western two-row could be produced in quantity it might compete in this industry. Even this grade would not be considered equal to the better class of barley but it would compete with the Danish, Scottish and Polish barleys.

2. *Six-rowed brewing barley.* The six-rowed barley which constitutes from 15 per cent to 40 per cent of the brewers "Mix", brings just as high prices for good quality as the two-rowed. The best quality of this barley is produced in California and Chili, while a lower quality is procured from the Mediterranean countries. A good six-rowed barley must be:—

(a) Sunny or bright in colour, denoting high vitamin and enzyme content.

(b) Low protein content, not more than 10 per cent to 11 per cent.

(c) Thick in the hull, to facilitate quick drainage in the mash tun.

(d) High in germination, practically 100 per cent.

The only variety produced in Canada which approaches this type is Trebi. At present it is too coarse in appearance, too high in nitrogen content, and not mellow enough. It is probably in this industry that the plant breeder has the greatest opportunity. If Trebi can be improved to approach the quality of Californian Bay Brewing, a market for 10,000,000 to 15,000,000 bushels might be secured. Until this type has been improved farmers in favourable areas may be able to produce a fine, clean, bright, uninjured sample of Trebi that will find a limited market with some of the less fastidious malsters and brewers.

Grades for the six-rowed barley brewing trade. To supply barley for this trade and to encourage the farmers to produce it, grades for Trebi barley were instituted as follows:—

> No. 1 Canada Western Trebi Barley shall be composed of 95 per cent barley of Trebi type, shall be plump, bright, sound, clean, practically free from other grain and weigh not less than 50 pounds to the bushel.
>
> No. 2 Canada Western Trebi Barley shall be composed of 95 per cent barley of Trebi type, shall be reasonably clean, sound, reasonably free from other grains, but not bright or plump enough to be graded No. 1, and weighing not less than 49 pounds to the bushel.
>
> No. 3 Extra Canada Western Trebi Barley shall be composed of 90 per cent barley of Trebi type, shall be reasonably clean, sound, reasonably free from other grains, but may include weather stained barley and weigh not less than 48 pounds to the bushel.

Other Industries

In other industries, such as the manufacture of yeast, vinegar, malt, stock food, etc., the O.A.C. 21 type will give best results. The six-rowed grades No. 2, and No. 3 Extra Canada Western as outlined for the malt extract trade should prove quite satisfactory.

Denmark

Denmark imports annually 2,000,000 to 4,000,000 bushels of barley. This is largely used for feed and varies, depending upon the amount and

quality of the home grown barley. If the quality of the domestic crop is high, it is exported for industrial purposes and cheaper feed barley is imported.

Feed barley. The Danish farmers prefer the barley from the Danube, because it is cleaner, more mellow than Canadian and therefore, makes a better looking meal. They want a good product and are willing to pay for it. For this market a cleaner, plumper feed grade is required. A barley suitable for the English feed trade would be suitable for Denmark. Therefore, the No. 3 Canada Western barley as outlined for the English feed barley trade is well suited to this market.

Malting barley. In the malting trade a small amount of six-rowed barley is imported to mix with their own two-rowed. This is procured from California and Bessarabia. Therefore, an improved type of Trebi might suit the trade. The grades would be No. 1 and No. 2 Canada Western Trebi.

Germany

Germany is the largest barley importing country in the world, importing around 75,000,000 to 80,000,000 bushels per year. Of this amount, Canada supplies 5,000,000 to 8,000,000. Barley is used for brewing, malt coffee, pot and pearl barley and feed for hogs.

Brewing. Germany produces most of the barley used in brewing and if there is not sufficient buys the right quality barley from her neighbours, such as Czecho-Slovakia, Poland and Denmark. Canada, therefore, has no chance of competing in this trade. No. 1 and No. 2 Canada Western two-row would be the only grades that would be considered.

Pot and pearl barley. Since England, by legislation, has prohibited the bleaching of barley, Germany has become the big pot and pearl barley manufacturer of Europe. It is estimated that this trade utilizes about 16,000,000 bushels. A good quality of white skinned Canadian barley might be used in this trade if it were admitted by customs on a parity with other countries. No. 2 and No. 3 Extra Canada Western Two-row barley as outlined for use in the English pot and pearl barley trade would be quite suitable.

Malt coffee. In Germany about 16,000,000 bushels of barley are also used annually in the manufacture of malt coffee. In this trade Canadian barley would be well suited, if the tariff were such that Canadian industrial barley could be imported. The duty on barley is 50 marks per metric ton from countries that have a trade treaty with Germany, and 70 marks per metric ton from countries which have not a trade treaty. Therefore, Canadian barley has to pay 20 marks per ton more than all other barley exporting countries, excepting Australia. This means 11 cents per bushel, which practically excludes Canadian barley for industrial purposes.

If Canada could come in on this trade, No. 3 Extra Canada Western Two-row would be well suited and probably No. 3 Extra Six-row could be used.

Feed barley. Germany's barley imports are largely for feeding purposes. The Canadian and American barley is used for this purpose. Germany insists that the barley must be clean. If it contains over 12 per cent wild oats, the customs may place 30 marks per ton more duty on it. The Bremen Association of Barley Importers, the largest feed barley

port in Germany, have in the past prohibited its members from importing Canada Western Feed Barley, because it contains 18 per cent wild oats. Hamburg and Dusseldorf had a similar regulation.

Grade for feed trade. The German grain merchants, millers and feeders were all emphatic that if a grade better than the old feed and rejected grades, but not quite so good as the old No. 4 Canada Western were established, there would be a big demand in Germany for it. To supply this demand No. 4 Canada Western barley was defined as follows:—

> No. 4 Canada Western Barley shall be barley composed of any variety or type or combination of varieties or types, shall be sweet, and may include damaged or stained barley and shall not weigh less than 46 pounds to the bushel.
>
> The regulations stated that it may contain 10 per cent of other domestic grain, wild oats and seeds singly or in combination, seeds not to exceed 3 per cent.

Holland, Belgium and Switzerland

In Holland, Belgium and Switzerland much the same situation exists as in Germany, first, because the imports into the first two countries are largely for transhipment up the Rhine into Germany, and second, the local conditions are much the same, for example, in Belgium there is a duty of 6 francs per 100 kilograms, if the barley contains 15 per cent wild oats, so that cleaner feed barley is also in demand in this country. The No. 4 Canada Western barley as now constituted should find a ready market for feed in all these countries.

In the brewing trade, grain of the quality of No. 1, No. 2 and No. 3 Extra Canada Western Trebi might be used in Belgium.

Canada

Canada uses a large amount of barley for feed, most of it is utilized on the farm where it is grown, consequently the quality is of little importance. Canada however, imports about 449,086,440 pounds of corn per year from the United States. For hog feeding, barley is better than corn, and for other stock it is almost equal to corn. The Eastern feeder is accustomed to clean corn and will not substitute for it dirty barley. Therefore, if this trade is to be secured, cleaner barley will have to be supplied. This refers particularly to the amount of black seeds which feeding experiments have indicated are worse than useless for feed. The wild oats while reducing the value of the barley for hog feeding make very good cattle and sheep feed. For hog feeding No. 4 Canada Western will probably give the best results, while for cattle feeding No. 5 and No. 6 Canada Western can be used to good advantage. The last two grades are defined as follows:—

> No. 5 Canada Western Barley shall include damaged and badly weathered barley and shall not weigh less than 42 pounds to the bushel.
>
> NOTE: (May contain 18 per cent of other domestic grain, wild oats and seeds, singly or in combination, seeds not to exceed 3 per cent.)
>
> No. 6 Canada Western Barley shall include all barley excluded from the preceeding grades on account of weight or admixtures.

NOTE: (May contain 25 per cent of other domestic grain wild oats and seeds, singly or in combination, seeds not to exceed 3 per cent.)

Malting trade. In Canada about 6,000,000 bushels of barley are used annually for malting. The malt is used in the manufacture of malt food, malt extract, etc., and in the brewing and distilling trades. In this country with the method of malting followed, the O.A.C. 21 type of barley gives the best results. For this trade the No. 3 Extra Canada Western Six-row barley is in demand.

CONCLUSIONS

Barley is used as raw material for a great number of products. Many of these products require a different standard of quality of barley. Even the same product in different countries may require different barleys. The market is a "sellers" market, therefore, Canada must supply the standard of barley required by the different industries or lose the trade to her competitors. The first step in this endeavour is to institute grades that will segregate barley into the different standards required by the trade, the second for the plant breeder to develop strains of barley better suited to the various industries, the third to determine the areas in Western Canada that will produce a barley suited to the different phases of the trade and the fourth, the farmers must produce the best quality within their power. The first step has been accomplished, new grades to suit the trade have been instituted. It now remains for the other institutions to do their part if Canada is to extend or even maintain her present barley markets.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the assistance of the Canadian Wheat Pool, which made possible this investigation by financing the writer and placing at his disposal their overseas facilities, the Walter Gilling Company, Ltd., who supplied means of transportation, Mr. Paul Bredt, a director of the Canadian Wheat Pool, who accompanied the writer, and all the barley marketing, transporting and manufacturing organizations, both in Canada and abroad, which placed their experience and facilities at the writer's disposal.

THE RELATION OF MATURITY IN THE APPLE TO RELATIVE WINTER INJURY *

Byron H. Wilson

University of Minnesota, St. Paul, Minnesota

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Apple varieties differ in their ability to withstand low winter temperatures. The physiological means through which this difference is expressed is not exactly known, though a number of studies have been made which have helped to clarify the problem. The study herein reported was made to determine if certain habits of growth were associated with the ability of seedling varieties to withstand low winter temperatures. The aim of the work was not necessarily to discover any physiological basis for winter hardiness, but to determine if certain habits of growth were of any value to the fruit breeder in the selection of hardy varieties. The characters chosen for this study were time of leaf fall and twig elongation because they were thought to give an index of maturity. Early maturity has been considered by many workers to have an important bearing on the winter hardiness of a variety, though no actual data concerning this point have been published.

The study was made at the University of Minnesota Fruit Breeding Farm about twenty-five miles west of Minneapolis. The climate here is continental in type, the thermometer usually dropping to —20°F. every winter, and every four or five years will reach —25°F. This is so severe that tender varieties are injured in varying amounts every winter.

The trees studied were seven and eight years of age, differing somewhat in size, as would be expected in a planting of mixed varieties. No top-worked trees were used, unless that work had been done more than two seasons previously.

Methods of Making Determinations

Winter injury. Samples of twigs were taken early in March, 1928. These were packed in moist sawdust and ice which would keep the temperature somewhere from 32°F. to 34°F. In March, 1929, samples were again taken from all trees previously recorded. They were treated similarly to those of the previous season.

The amount of injury was estimated by the method devised by Beaumont and Hildreth †. In this method, an estimate of the browning of the tissues is used as an approximation of the percentage of cells killed. "Six such classes were established, and for convenience were give numerical values as: 0—no browning; 1—trace; 2—slight; 3—medium; 4—dark; 5—very dark". This estimate of browning is made in nine areas of the twig, hence, when every tissue is dark brown it is respresented by a total injury score of 45, and on the other hand no injury would have a score of 0. The regions examined are shown in Figure 1.

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†Unpublished.

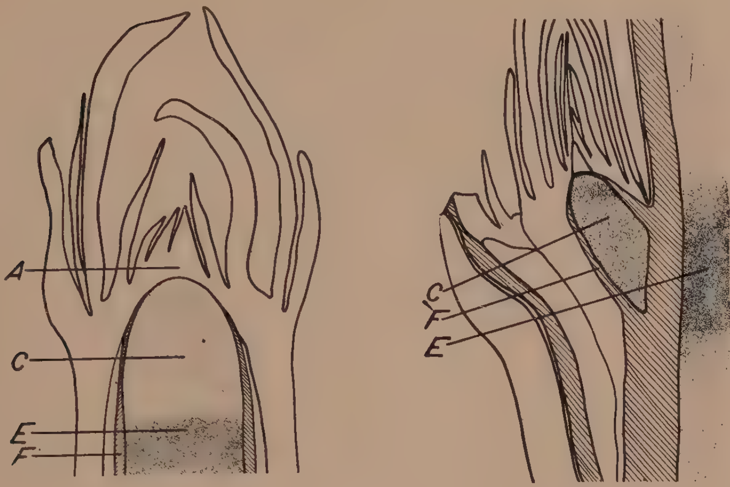

Figure 1. Regions of apple buds used in the Beaumont—Hildreth analysis for winter injury.

Terminal Bud:
A. Primordial Meristem.
C. Undifferentiated Pith.
E. Differentiated Pith.
F. Primary Xylem.

Lateral Bud:
C. Undifferentiated Pith.
E. Nodal Pith.
F. Primary Xylem.

Leaf fall. The measure of the time of leaf fall was necessarily arbitrary. In determining the time of leaf fall, the amount of foliage persisting on a given date was estimated in precent of the estimated normal for the tree in full leaf. The leaf fall estimates were made twice following the 1927 season and averaged, the estimates being made in March, 1928. In the second season they were made on October 14, October 24, November 11 and December 5. The estimates of October 14 were not considered reliable as very few leaves had then fallen, making it practically impossible to draw fine enough distinctions. By December 5 practically all the leaves had fallen from all varieties. Consequently, the data on leaf fall that were used came from the estimates made on the other two dates.

Twig elongation. The amount of growth was determined by measuring the length between the annual ring and the base of the petiole of the smallest terminal leaf. These measurements were made on dates grouped about June 26, July 20, August 9 and August 29. To keep the measures of twig elongation of succeeding periods comparable, the same twigs were measured each time, so twenty normal, vigorous, terminal shoots on the outer periphery of the tree were tagged. When the experiment was started, it was planned to find the variability of the growth of the twenty tagged twigs of each tree. The second measurement, however, revealed the fact that two shoots in apparently similar growing conditions varied markedly in the amount of growth. In no case did all the twigs of a tree stop growing during the same period. As the growth of the tree and not that of any particular group of twigs was desired, the average growth for twigs was considered the best measure of the tree's behaviour.

The trees on which the work was done were located in two different types of environment. One group of 93 trees was located on level land while the other group made up of 63 trees, was located on a southwest sloping hillside. These trees were obviously in two different types of environment where soil, moisture supply and temperature all varied to a considerable extent. Hence, the correlations are reported in paired form, the first one being the result obtained from the trees on the level ground (level), and the second one being the result obtained from the trees on the south-west facing slope (slope).

Seasonal Relationship of Winter Injury

The amount of winter injury was very similar for the two seasons. The coefficient of correlation between winter injury of the two seasons for the trees on the level ground was .60 ± .045. On the slope the correlation between the injuries of the two seasons was .73 ± .040. As there was a distinct correlation between winter injury of the trees for the two seasons, a study was made to determine the consistency of behaviour of other characters for the two seasons, and also the relation of these characters to winter injury.

Seasonal Relationship of Leaf Fall

Certain varieties began to drop their leaves before the middle of October, and in the season of 1928 all the varieties had dropped all of their leaves by December 5. In the previous year, 1927, some of the leaves of most of varieties persisted throughout the winter, enabling data to be taken on them the following spring in March, 1928. The behaviour of the trees in regard to leaf fall as determined in March, 1928, was related to their behaviour in the following October and November. As shown in table 1, the correlation coefficients are significant, and there is little difference between the trees located on the slope and those located on the level ground. There were small but significantly higher correlations between the March and November leaf fall estimates (level .62 ± .043, slope .56 ± .058) than between the March and October leaf fall estimates (level .41 ± .058, slope .44 ± .069); although the correlations between leaf fall of October and November (level, .63 ± .042, slope .75 ± .036) were relatively high. The higher correlation obtained between the leaf fall of March and November is of some significance in the light of the relationship found to exist between leaf fall and winter injury as it tends to indicate that the later determinations are the most valuable.

Table 1.—*Correlations between the percentage of leaves persisting at various times.*

		Oct. 1928	Nov. 1928
March, 1928	Level	.41 ± .058	.62 ± .043
	Slope	.44 ± .069	.56 ± .058
October, 1928	Level		.63 ± .042
	Slope		.75 ± .036

Relationship between Leaf Fall and Winter Injury

The estimates of persistent leaves were found to have a wide range of relationship with winter injury. The correlations between winter injury of 1927-1928 and leaves persisting on the trees in March were (level, .52 ± .051), and (slope, .59 ± .056). These show a distinct relationship which, however, is not found in the following season, when the correlations between winter injury and percentage of persistent leaves was found to be much lower. It will be seen from table 2 that there was no significant correlation between injury during the winter of 1928-1929 and the number of persistent leaves in either October or November of the previous autumn.

TABLE 2.—*Relationship between the percentage of persistent leaves in the autumn of 1928, and the injury received during the following winter.*

		Leaves persisting on the trees. Oct. 21, 1928	Nov. 11, 1928
Winter Injury	Level	−.01 ± .070	.19 ± .067
of 1928-1929	Slope	.21 ± .081	.15 ± .083

However, if low temperatures had commenced early in the season, it is probable that higher correlations would have been found, as indicated by freezing experiments. On October 14, 1928, twigs were cut from thirteen trees in widely different stages of leaf fall. They were loosely packed in a cardboard box, tightly wrapped in paper and subjected to 0°F. for 15 hours. The twigs were then held at room temperature for a week to allow any injury to become manifest before analyzing. The data from these thirteen trees is plotted on a graph (Figure 2). It will be observed that one tree gave a result not consistent with the rest of the group. This tree on careful examination was found to have been girdled so low as to have escaped previous notice. A straight line was fitted to the data from the other trees. It will be seen that there is a fairly good fit, showing that the relationship between injury by cold and percentage of leaves persisting does exist though it may be changed or covered up before the final winter freeze up, as correlations between winter injury and leaf fall of a week later were not significant.

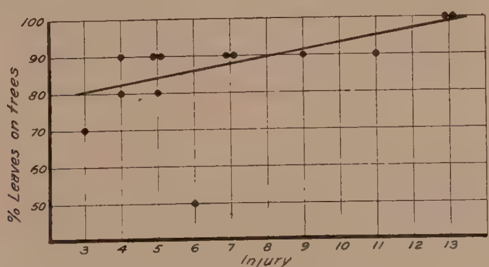

Figure 2. Relationship between the percentage of leaves on the trees on Oct. 12, 1928, and the amount of injury due to freezing for 15 hours at 0°F.

That there is a real difference between the two seasons may be shown by comparing the correlations between winter injury and leaf fall of the first season with those of the second season (table 3). The difference between

the correlations, using the trees on the level, was 4.31 times the probable error while the difference for the trees on the slope was 3.99 times the probable error. These differences are so large that the odds are very great that they represent real differences. It is probable that weather conditions caused this result, as the two seasons were markedly different, particularly in regard to temperature.

TABLE 3.—*Differences between the correlations of winter injury and leaf fall of 1927-1928, and of 1928-1929.*

	Level	Slope
'r' between leaves persisting in March 1928 and injury of 1927-1928.	.52 ± .051	.59 ± .056
'r' between leaves persisting on Nov. 11, 1928 and injury 1928-1929.	.19 ± .067	.15 ± .083
Difference	4.31×P.E.	3.99×P.E.

From the meteorological data (Figure 3) it is seen that the late autumn and early winter temperatures of 1927 were much lower than were those of 1928. It is suggested, to explain the differences in the correlations, that if low temperatures appear in the autumn and early winter, there will be a fairly close relationship between percentage of leaves persisting and the amount of winter injury. However, if the late autumn temperatures are higher, the trees are able to mature their leaves, which form abscission layers and drop normally. In such a case, the correlation will probably be of little significance.

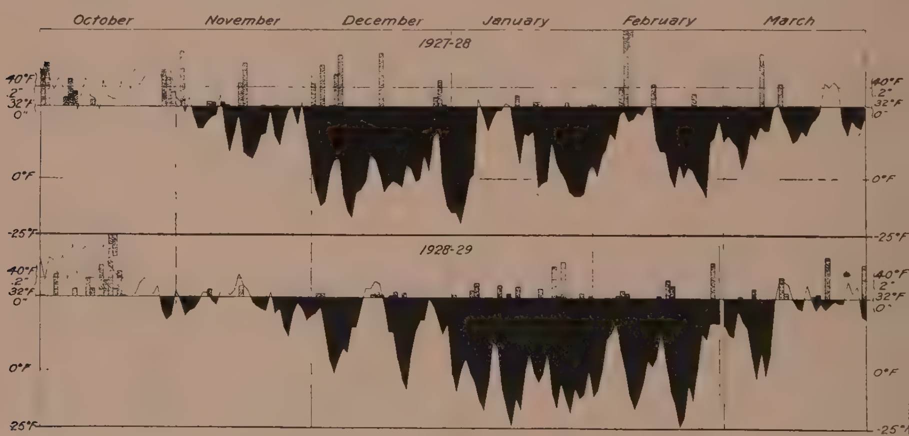

Figure 3. Daily precipitation and minimum temperatures for the six coldest months of 1927-28 and of 1928-1929.

The daily minimum temperatures below 32°F are black.

The stippled areas represent rainfall. 40°F and .2 inches of rainfall are both represented by the same line.

Even though such a thing may happen, it is found that correlations between leaf fall of one season and winter injury of another season are significant. Five out of six correlations, showing this relationship are distinctly significant, while one is not (table 4). Such correlations would indicate that there is a degree of constancy in the behaviour of trees in different seasons.

TABLE 4.—*Correlations between amount of persistent leaves of one season, and the winter injury of another season.*

	Level	Slope
Winter injury of 1928-1929, correlated with persistent leaves in March, 1928.	.31 ± .063	.35 ± .074
Winter injury of 1927-1928, correlated with persistent leaves on: Oct. 21, 1928	.18 ± .068	.42 ± .070
Nov. 11, 1928	.45 ± .056	.41 ± .070

The correlation of little significance for October 21 (level .18 ± .068) when compared with the similar correlation for November 11, 1928 (level .45 ± .056) showed a difference of .27 ± .088, which probably is significant. In table 1 the correlation between leaves persisting November 11, 1928, with those in March, 1928, was (level .62 ± .043), and between leaves persisting on October 21, 1928, with those in March, 1928 was (level .41 ± .058). The difference between these correlations is .21 ± .065. These two differences, taken with other smaller differences throughout the experiment as well as the writer's experince in making leaf fall estimates when only a small proportion had fallen, lead one to conclude that estimates of leaf fall made before at least half of the leaves have fallen, are of little value.

In general, the results indicate a relationship between the amount of winter injury and the time when leaves are dropped. If life processes are interrupted by cold weather early in the autumn the percentage of leaves persisting will give a good indication of the amount of winter injury, but if the trees have been able to mature and drop their leaves before cold weather commences, then at no time in the autumn will leaf fall show any marked relationship to winter injury.

GROWTH RELATIONS

There seemed to be two rather closely related measures which would give a gross indication of the cessation of active twig growth. One may be represented as a growth curve of the twigs, giving an idea of when growth was at its maximum and when it became very slow. The other is given by the date of setting the terminal, which would really be an expression of the end point on the growth curve. However, it was found to be impossible to get satisfactory data on the setting of the terminal buds, because the abnormally dry period early in the summer, followed by a rainy period, caused a large number of trees to set their terminal buds and later have them break open.

As noted before, the amount of growth was measured at four dates during the summer. The fourth period, when growth was least, was found to be highly correlated with the third (level .63 ± .042, slope .88 ± .019) poorly correlated with the second (level .27 ± .065, slope .08 ± .084) and was not correlated at all with the first period (table 5). The third period was found to be moderately correlated with the second (level .60 ± .045, slope .23 ± .080) and was not correlated at all with the first period. The second period was correlated with the first period in one case (level —.05 ±

.070, slope .43 ± .069). These relationships are not altogether surprising when it is considered that the growth during the first period will be partly due to the amount of food stored by the plant during the previous season while in the later periods this will not be a factor.

TABLE 5.—*Correlations between the amount of growth during four different periods in the summer of 1928.*

		1. Growth Spring-June 26	2. Growth June 26-July 20	3. Growth July 20-Aug. 9
4. Growth Aug. 9-Aug. 29	Level Slope	.14 ± .069 .08 ± .084	.27 ± .065 .08 ± .084	.63 ± .042 .88 ± .019
3. Growth July 20-Aug. 9	Level Slope	−.14 ± .068 .14 ± .083	.60 ± .045 .23 ± .080	
2. Growth June 26-July 20	Level Slope	−.05 ± .070 .43 ± .069		

The relationship between the amount of growth made during the different periods and winter injury was found to be practically zero (table 6). A table similar to this one was obtained when measurements of growth were expressed in percentage of the total season's growth. Hence, one would conclude that different varieties, under the conditions of the experiment in which growth as manifested by twig elongation is retarded earlier in the autumn, are no hardier than are those in which growth continues to a much later date. The same variety, however, under different environmental conditions, may or may not vary in hardiness in relation to the time of cessation or to the amount of growth.

TABLE 6. *Relation between growth during different periods of summer and winter injury*

		Injury of 1927-28	Injury of 1928-29
Growth to June 26	Level Slope	.01 ± .070 .20 ± .082	−.03 ± .070 .24 ± .080
Growth June 26 to July 20	Level Slope	.02 ± .070 .19 ± .082	.14 ± .068 −.03 ± .085
Growth July 20 to Aug. 9	Level Slope	−.18 ± .068 −.15 ± .083	−.16 ± .068 −.15 ± .083
Growth Aug. 9 to Aug. 29	Level Slope	−.03 ± .070 −.08 ± .084	−.02 ± .070 −.10 ± .084

Nor was there any relation found between twig growth and the percentage of leaves persisting at various dates in the autumn. It will be seen (table 7) that there are only two coefficients of any significance in the first three columns, and these are small. The first, between percentage of leaves persisting November 11, 1928 and growth June 26—July 20, was (level —.24 ± .066) and the other, between percentage of leaves persisting November 11, 1928 and growth July 20—August 9, was (level —.27 ± .065). The data from columns 1, 2 and 3 was recalculated using percentage of season's total growth for each tree, instead of actual measurements; only one substantial

change in the whole table was found. This is shown in table 7, column 4, which is now (.27 ± .065) instead of (.01 ± .070). This change is probably due to the great variation in the amount of total growth made by the different trees. However, it cannot be explained why there is a series of three significant, though very small, correlations in this one column and none in the rest of the table.

TABLE 7. *Correlations between growth made during different parts of the summer and per centage of leaves persisting at various dates.*

		Percentage of leaves persisting on trees			
		Spring 1928 March Column 1*	Autumn 1928 Oct. 21 Column 2*	Autumn 1928 Nov. 11 Column 3*	Autumn 1928 Nov. 11 Column 4*
Growth Spring-June 26	Level	.10 ± .069	.13 ± .069	.01 ± .070	.27 ± .065
	Slope	.13 ± .063	.18 ± .082	.17 ± .083	
Growth June 26-July 20	Level	−.06 ± .070	−.07 ± .070	−.24 ± .066	−.22 ± .066
	Slope	−.02 ± .085	−.15 ± .083	−.08 ± .084	
Growth July 20-Aug. 9	Level	−.09 ± .069	−.06 ± .070	−.27 ± .065	−.24 ± .066
	Slope	−.08 ± .084	−.01 ± .085	−.01 ± .085	
Growth Aug. 9-Aug. 29	Level	−.02 ± .070	.00 ± .070	−.10 ± .069	−.04 ± .070
	Slope	.08 ± .084	.08 ± .084	.13 ± .083	

*Columns 1, 2 and 3 were calculated using the actual measurements of growth in cms. Column 4 was calculated from the same data as was column 3, but it was treated as percentage of the total season's growth.

It would seem that the correlations show fairly definitely that there is no obvious relationship between the time or the amount of twig elongation and winter injury. If such a relationship exists, it must be so inter-related with other factors that of itself it means nothing.

Effect of Environment

From the beginning it has been assumed that the 93 trees on the level ground and the 63 on the southwest facing hillside were in different environment. To prove this, the correlation coefficients resulting from these two groups of trees were compared in the light of their probable errors (table 8). From the column marked odds it will be seen that such differences, if due to chance, could not happen very frequently. In other words, there is probably a real difference here, but whether or not it affects the resistance of the trees to winter injury is not known.

Conclusion

The measures of maturity studied showed different degrees of relationship to winter injury. Twig elongation seemed to have little correlation to either leaf fall or winter injury. On the other hand, leaf fall showed a significant relationship to winter injury. Further study will probably show that if apple trees retain a large proportion of their leaves until late winter, there will be a fairly close relationship between the percentage of leaves still hanging and the amount of winter injury. However, when the trees mature normally in the autumn and all their leaves eventually drop, at no time during the autumn will percentage of leaves persisting bear any appreciable relationship to winter injury.

TABLE 8. *Comparison between the reactions of the group of trees on the level upland with those on the southwest facing hillside.*

Correlations between		Level	Slope	Difference	Diff. P.E.	Odds
Leaves persisting Oct. 21	Leaves persisting Nov. 11	$+.6311 \pm .0421$	$+.7560 \pm .0364$	$.1269 \pm .0556$	2.25	7
Leaves persisting Oct. 21	Winter injury Season 1.	$+.1823 \pm .0676$	$+.4228 \pm .0698$	$.2405 \pm .0972$	2.47	9
Winter injury Season 1.	Winter injury Season 2.	$+.5952 \pm .0452$	$+.7308 \pm .0396$	$.1356 \pm .0600$	2.26	7
Growth to June 26	Growth July 20 to Aug. 9	$-.1411 \pm .0685$	$+.1377 \pm .0834$	$.2788 \pm .1079$	2.58	11
Growth to June 26	Growth June 26 to July 20	$-.0477 \pm .0698$	$+.4343 \pm .0690$	$.4820 \pm .0981$	4.91	1081
Growth June 26 to July 20	Growth July 20 to Aug. 9	$+.5952 \pm .0452$	$+.2315 \pm .0804$	$.3637 \pm .0922$	3.94	126
Growth July 20 to Aug. 9	Growth Aug. 9 to Aug. 29	$+.6284 \pm .0423$	$+.8820 \pm .0189$	$.2536 \pm .0463$	5.48	9010

SUMMARY

1. The winter injury of 1927-28 was closely correlated with that of 1928-29, although the seasons were extremely different.
2. No correlation existed between winter injury and leaves held until late fall unless some of the leaves persisted through the winter, in which case the correlation was fairly high.
3. There was a fairly high correlation between percentage of leaves persisting in October, percentage of leaves persisting in November, and percentage of leaves persisting in March of another season.
4. Between growth during different periods in the summer and extent of winter injury, there was no correlation.
5. The growth during the early part of the summer bore no relationship to any that followed, but as the season advanced the relationship became close.
6. Between percentage of leaves persisting in the fall and twig elongation during different periods in the summer, there existed a relationship only in one series of estimates of leaf fall, and these were slight.
7. The southwest facing slope and the level ground gave similar winter injury results, but other relationships showed marked differences indicating two different environments. To what extent winter injury was affected by environmental differences could not be determined.

ACKNOWLEDGEMENTS

The writer wishes to express appreciation to Professor W. H. Alderman and Dr. J. H. Beaumont for help in planning this experiment. Thanks are also tendered to Dr. H. K. Hayes and Dr. F. R. Immer of the Department of Plant Genetics, and Dr. F. A. Krantz, Dr. A. N. Wilcox, Dr. T. M. Currence of the Department of Horticulture, for advice in making up the data, to Mr. F. E. Haralson, Superintendent of the Fruit Breeding Farm for help in collecting the data and to Mr. T. S. Wier for help in the organization.

TIME OF PLOWING BROME GRASS SOD IN RELATION TO THE YIELD AND QUALITY OF THE SUCCEEDING WHEAT CROP *

R. NEWTON † AND J. G. MALLOCH ‡
University of Alberta, Edmonton, Alberta.

INTRODUCTION

Next to the choice of superior, well-adapted varieties, the use of good cultural methods provides the best opportunities for improving at the same time both the yield and quality of our wheat crop. It is true that the major fluctuations in the yield of the crop are brought about by variations in seasonal rainfall. Unfortunately an increase in yield due to favourable rainfall is accompanied very often by a lowered quality. The same is likely to be true of increases in yield produced by irrigation. Fortunately there is no such offset to increases in yield brought about by better tillage methods or rotations, these commonly improving both yield and quality.

The time of plowing grass sods is one tillage operation which, in experiments at the University of Alberta, has been observed to cause marked variations in the yield and quality of succeeding crops. This has been attributed mainly to three factors, (1) progressively more incomplete killing of the grass with later plowings, (2) less time for decomposition of the sod and nitrification in the later plowings and (3) less storage of moisture in the shorter partial fallow after the later plowings. The first of these factors has special significance with regard to creeping-rooted grasses such as brome.

CONTROL OF BROME GRASS AND YIELD OF WHEAT

One of the most important problems in the use of brome grass in rotations is that of eradicating the plants when the sod is broken. It is held in many quarters that two plowings are necessary to control creeping-rooted grasses such as brome. However, our experiments suggest that one plowing, if made at the right time, will at least go a long way towards that end. Two such experiments have been carried out here. In both cases two-year-old brome sods were plowed at a series of progressive dates, and observations made of the yields of the succeeding wheat crop as well as of the number of volunteer brome plants in the stubble.

In the first experiment, a piece of brome grass seeded in 1918 was divided into four plots, plowed at the dates shown in table 1, which includes also the yields of wheat sown on the breaking.

Actual counts of the number of volunteer brome plants were not made in the field, but photographic records of representative areas show very few plants in the wheat stubble on the August 1st plowing, and large numbers in the October 1st and spring plowings, the last having the largest number. The range was in the order of roughly 2 or 3 per square yard in the first plowing, to 30 or 40 per square yard in the spring plowing. (Plate I).

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*Paper No. 11 of the Associate Committee on Grain Research, National Research Council of Canada.
†Professor of Field Crops.
‡Research Assistant.

Plate 1.—Representative square yards of wheat stubble showing volunteer brome plants in plowings of (I) August 1, 1920, (II) Spring, 1921.

TABLE 1.—*Time of plowing in relation to control of brome grass and yield of wheat, 1920-21.*

Time of plowing.	Yield per acre.
	Bushels
Aug. 1, 1920	21.4
Sept. 1, 1920	12.2
Oct. 1, 1920	8.3
Spring, 1921	13.2

The yield of wheat fell off quite rapidly with later fall plowing. The spring plowing was followed by a better yield than the latest fall plowing, but as a method of controlling brome it must be regarded as a complete failure. The general smallness of the wheat yields is explained by the dryness of that season.

The second experiment was carried out in 1926-27 on brome sod seeded in 1924. The sod was in a strip about 22 rods long by a little over 4 rods wide. The strip was divided crosswise into 15 plots, to accommodate five different times of plowing, each in triplicate. The plots were packed after plowing, and given sufficient cultivation at intervals to keep green growth down. In table 2 are given the time of plowing, average yield of wheat from the triplicate plots, and the average number of volunteer brome plants per square yard. This last was determined by counting the number of plants in four representative square yards on each plot, about three weeks after the wheat had been cut.

TABLE 2.—*Time of plowing in relation to control of brome grass and yield of wheat, 1926-27*.

Time of plowing.	Volunteer brome plants per sq. yd.	Yield per acre.
	No.	Bushels
July 16, 1926.	1.7	36.2
Aug. 16, 1926.	3.0	36.2
Sept. 20, 1926.	4.7	37.5
Oct. 15, 1926.	9.7	30.8
April 25, 1927.	17.3	29.4

Probably because the abundant rainfall of 1926-27 supplied sufficient moisture both for the decomposition of the sod and the growth of the wheat crop, there is little difference in the wheat yields, except from the latest fall and spring plowings, which are appreciably smaller. The most interesting feature of the results is the number of volunteer brome plants. This experiment, like the first one, shows clearly the advantage of early plowing in the control of brome grass.

To explain this it may be pointed out that cutting the hay crop promptly after flowering, and plowing immediately after the hay is removed, turns up the root-stocks of the brome grass at a time when they are relatively depleted of food reserves and not in a condition to send out vigorous shoots. Furthermore, early plowing exposes the root-stocks to the drying effects of the summer sun and winds. The greater effectiveness of even the latest fall

plowing as compared with the spring plowing may perhaps be similarl[y] attributed to the exposure of the root-stocks to the drying and freezin[g] effects of winter.

Quality of the Wheat Crop

In the second experiment, bulked samples of the wheat from each set o[f] triplicate plots were used for determinations of some quality factors. Th[e] results are given in table 3.

Table 3.—*Time of plowing in relation to quality of wheat, 1926-27.*

Date of plowing.	Weight per bushel	Yield per acre	Protein in wheat (13.5% moist.)	Yield of protein per acre.
	lbs.	bushels	%	lbs.
July 16, 1926	59½	36.2	9.7	211
Aug. 16, 1926	61	36.2	9.3	202
Sept. 20, 1926	60½	37.5	9.1	205
Oct. 15, 1926	60	30.8	8.6	159
Apr. 25, 1927	60½	29.4	8.6	152

	Yield of patent flour	Protein in flour (13.5% moist.)	Baking Test. Absorption	Loaf volume	Texture	Colour	Baking* score.
	%	%	%	cc.			
July 16, 1926	50.0	8.2	60.9	463	9	8	66
Aug. 16, 1926	53.4	8.2	60.3	447	8	8	60
Sept. 20, 1926	53.0	7.8	59.6	442	8	9	60
Oct. 15, 1926	52.8	7.5	60.7	443	8	8	59
Apr. 25, 1927	52.0	7.4	60.2	395	6	8	43

*Baking score calculated by the formula:
(loaf vol.-400) 0.2 + (absorption −60) + (texture score) 3 + (colour score) 2 + (general appearanc[e] score). Perfect scores for texture, colour and general appearance are 10 each. In this experiment, the loave[s] were not scored for general appearance, and for purposes of this calculation were allowed a perfect score o[n] this point. The baking score is therefore a little too high in all cases.

The year 1927 was a low-protein year throughout western Canad[a] generally. The wheat harvested from these experimental plots was especiall[y] low, the general seasonal effect being accentuated by the sequence effect o[f] the grass. In general, wheat after fallow is highest in protein content, wit[h] that grown after legumes, cereals and grasses following in descending orde[r,] the lowest protein coming after grasses. The low protein content is reflecte[d] in the comparatively poor baking quality of all samples. The highest bakin[g] score was only 66, whereas a really first-rate sample of wheat should give [a] score approaching 100.

There are, however, significant differences in quality caused by the tim[e] of plowing. The yield of protein per acre, which is a very useful measur[e] of soil and seasonal effects, since it combines in one expression the yield o[f] grain and its protein content, is markedly reduced in the latest fall plowin[g] and in the spring plowing. The baking quality shows a tendency to fall o[ff] continuously as the date of plowing is deferred, and tails off abruptly in th[e] spring plowing.

The differences in weight per bushel and flour yield are scarcely signif[i]cant for any of the samples. The slight disadvantage of the earliest plowin[g] in this respect is compensated by its higher protein content and baking qualit[y].

The essential similarity of the yields of grain from the first three plowings has already been attributed to the abundant rainfall of that season. It is to be remembered, however, that in the less favourable season of 1920-21, the yield per acre fell off much more rapidly with deferred plowing, and the control of brome grass in the later fall plowings was also less satisfactory.

Conclusion

It must be concluded from these experiments that for conditions such as obtain at Edmonton it is advisable to plow brome sod in July or early in August, and follow with cultivation as needed to keep down green growth. As compared with later plowings this practice will ensure in an average year a more satisfactory control of the brome grass and both a better yield and better quality of wheat.

BOOK REVIEW

Wheat, the Riddle of World Markets.—By C. W. Peterson, Editor of the Farm and Ranch Review, Calgary, Alta. (Farm and Ranch Review Ltd., 1930. Price $1.00).

This book appears to have been written at a very opportune time being a valuable contribution to an interesting subject. The author in addition to his editorial activities has written other books and has exceeded the hundred thousand bushel mark in wheat growing in several different years. This latter accomplishment adds interest to the book and at the same time explains in part the phase of the question presented which is largely that of the wheat grower.

The aim is to present to the business people of Canada the importance, past, present and prospective, of the business of wheat growing. World wheat prices, past, present and future, are considered. Wheat consumption and production of the world and the probable expansion of the industry is speculated upon. The methods of growing, marketing, price-making and control receive some consideration and the record of western Canada in growing wheat for the past quarter century is portrayed. Discussion of all these various factors within the compass of one hundred and twenty pages makes the book condensed.

Chapters particularly well done are those on agricultural mechanization and diversification versus specialization. In discussing the latter topic the reasons for specialization in wheat growing are clearly set forth and the possbility of Canada at some future date producing in favourable seasons as much as two billion bushels pointed out as a possibility.

This book, emphasizing as it does the grower's interest, is a good one to consider along with "The Bread of Britain" by A. H. Hurst, a member of the grain trade, who presents another slant on this subject, that of the consumer and the grain trade.

J.E.L.

WESTERN CANADIAN SOCIETY OF AGRONOMY

Report of Tenth Annual Meeting

The tenth annual meeting of the Western Canadian Society of Agronomy was convened in the auditorium of the Medical Building of the University of Alberta on December 27, 1929. The meeting was called to order by Dr. R. Newton. He introduced the president, Mr. M. J. Tinline, who then took the Chair.

Dean Kerr, Acting President of the University in the absence of Dr. Wallace, addressed the group with words of welcome and best wishes for a successful meeting.

The minutes of the previous meeting were read and approved on the motion of G. M. Stewart, seconded by J. H. Ellis.

A brief report on the arrangements for the meeting was made by the Secretary.

The presidential address was delivered by M. J. Tinline. He called the attention of the Society to the need for more thorough knowledge on some of our agronomic problems, especially those in which the agronomists and the livestock specialists have a joint interest.

Following the presidential address the Chairman continued with the programme as outlined.

The following special committees were appointed by the chairman:

Resolutions: L. E. Kirk, R. Newton and T. J. Harrison.

Nominations: F. H. Reed, G. M. Stewart and J. H. Ellis.

Membership: A. W. Henry, J. G. Taggart and A. T. Elders.

Auditors: S. Barnes and James Murray.

The two following resolutions were drawn up by the resolutions committee, presented to the Society, approved and immediately forwarded.

"Hon. W. R. Motherwell,

Minister of Agriculture, Ottawa.

The members of the Western Canadian Society of Agronomy in session at Edmonton extend to you the compliments of the season and express the hope that you will very soon enjoy complete recovery from your unfortunate illness."

"The President,

American Society of Agronomy,

Des Moines, Iowa.

Greetings from the Western Canadian Society of Agronomy in session at Edmonton. Best wishes for the success of your annual meeting and the future success of your esteemed organization."

The programme of papers and the discussions which took place at the meetings were as follows:

MORNING—FRIDAY, DECEMBER 27

Symposium—Barley Improvement and Production

Chairman: President M. J. Tinline.

(a) Genetics of Barley: G. F. H. Buckley, Dominion Experimental Farm, Brandon.
(b) Present Grading System and Market Demands of Barley: T. J. Harrison, Manitoba Agricultural College, Winnipeg.
(c) Harvesting and Care of Barley for the Market: H. G. L. Strange, Fenn. Alberta.

Discussions of:

(a) Led by K. W. Neatby, Dominion Rust Research Laboratory, Winnipeg.
(c) Led by Clyde C. Gillies, Strathcona, Alberta.

General discussion:

Mr. Hess, Canada Malting Co., Calgary.
G. M. Stewart, Dominion Seed Branch, Calgary.

AFTERNOON—FRIDAY, DECEMBER 27

Symposium—Range and Pasture Management.

Chairman: F. H. Reed,

(a) Range Management: L. B. Thomson, Dominion Range Experimental Station, Manyberries, Alta.
(b) A study of Our Range Pastures: S. E. Clarke, Dominion Range Experimental Station, Manyberries, Alta.
(c) Improvement of Our Native Grasses: F. H. Peto, University of Alberta.
(d) Alfalfa as a Forage Crop for Western Canada: J. R. Fryer, University of Alberta.
(e) The Role of Alfalfa in Livestock Feeding: R. D. Sinclair, University of Alberta.
(f) Abnormal Seed Development in Sweet Clover Species Crosses; A New Technique for Emasculating Sweet Clover Flowers: L. E. Kirk, University of Saskatchewan.

Discussion of:

(a) Led by James Murray, Provincial Department of Agriculture, Medicine Hat.
(b) Led by G. F. H. Buckley, Dominion Experimental Farm, Brandon.
(d) Led by Don H. Bark, C.P.R. Irrigation Investigation Branch, Brooks,
(e) Led by W. H. Fairfield, Dominion Experimental Station, Lethbridge.

General Discussion—G. P. McRostie.

BANQUET GIVEN BY UNIVERSITY OF ALBERTA

The members of the Society were entertained by the University of Alberta at a banquet on the evening of Friday December 27. Very interesting addresses were given by Dean E. A. Howes and Dr. Robert Newton, both of the University of Alberta.

MORNING—SATURDAY, DECEMBER 28.

Symposium—Crop Rotations

Chairman: T. J. Harrison

(a) Rotation as a Farm Practice (in Relation to Weed Control): D. A. Brown, Dominion Experimental Farm, Brandon.
(b) Rotations in Relation to Crop Diseases: A. W. Henry, University of Alberta.
(c) Rotations in Relation to Insect Control: E. H. Strickland, University of Alberta.
(d) Activity of Micro-organisms as Influenced by Rotations: J. D. Newton, University of Alberta.
(e) Rotations in Relation to Wheat Quality: J. G. Malloch, University of Alberta.

Discussion of:

(a) Led by F. S. Grisdale, Olds School of Agriculture.
(b) Led by R. C. Russell, Dominion Laboratory of Plant Pathology, Saskatoon, and W. C. Broadfoot, Dominion Laboratory of Plant Pathology, Edmonton.
(e) Led by J. E. Edgar, Vermilion School of Agriculture.

General Discussion:

The World Grain Show: H. A. Craig, Provincial Department of Agriculture, Edmonton.

AFTERNOON—DECEMBER 28.

Chairman: M. J. Tinline.

(a) The Inheritance of Resistance to *Puccinia graminis tritici* Erikss and Henn. in Crosses between Varieties of *Triticum vulgare* Host. K. W. Neatby and C. H. Goulden, Dominion Rust Research Laboratory, Winnipeg.
(b) Dates of Harvesting Wheat, Oats and Barley: G. E. DeLong, Dominion Experimental Station, Lacombe.
(c) Progress in Chemical Weed Eradication: S. H. Vigor, Saskatchewan Department of Agriculture, Regina.
(d) Effect of Superphosphate on the Quality and Yield of Wheat: W. L Jacobson, Brooks.
(e) Forage Crops in Great Britain and the Scandinavian Countries: G. P McRostie, Dominion Experimental Farm, Ottawa.

Special Committee:

Varietal Mixing: H. S. Fry, Saskatchewan Wheat Pool, Regina.

It was late in the afternoon of the second day before all of the papers and the discussions were completed. The report of the Special Committee on Varietal Mixing was then called for. H. S. Fry gave a most interesting report which was the result of a large piece of work. It was clearly evident that more work was necessary before any definite conclusions could be made. Considerable discussion followed, and it was finally moved by H. S. Fry and seconded by G. M. Stewart, "that the new executive ac

as a committee to take whatever action seems necessary to further the work of the Special Committee on Varietal Mixing." Passed.

The report of the Field Experimental Committee was presented by G. E. DeLong. It was suggested that this committee be discontinued and that special committees be appointed whenever special problems arise. Moved by H. S. Fry and seconded by E. C. Sackville that the report be adopted. Passed.

The report of the Crop and Seed Technology Committee was presented by G. M. Stewart and C. W. Leggatt. Moved by W. H. Fairfield and seconded by J. H. Ellis that the report be accepted. Passed.

The report of the Plant Pathology and Physiology Committee was presented by R. Newton. He referred to the Reports of the President of the National Research Council for the activities of the Pathologists. It was suggested that the committee be discontinued. Moved by G. M. Stewart and seconded by S. J. Sigfusson that the report be accepted. Passed.

A lengthy and detailed report by the committee on Plant Breeding and Genetics was presented by J. R. Fryer. It was suggested that the committee be discontinued. Moved by J. H. Ellis and seconded by S. H. Vigor that the report be accepted. Passed.

It was moved by G. E. DeLong to discontinue the standing committees as they had outlived their purpose or usefulness. Motion was withdrawn as it was suggested that each committee be considered separately.

Moved by L. E. Kirk, seconded by R. Newton that the committee on Instruction and Extension be discontinued. Passed.

Moved by G. E. DeLong, seconded by L. E. Kirk that the committee on Field Experimentation be discontinued. Passed.

Moved by J. R. Fryer, seconded by A. T. Elders that the committee on Plant Breeding and Genetics be discontinued. Passed.

Moved by G. M. Stewart, seconded by H. J. Breakey that the remainder of the standing committees be discontinued (Soils Investigations, Crop and Seed Technology and Plant Pathology and Physiology). Passed.

G. E. DeLong suggested that three special committees be appointed as follows:

1. Varietal Zonation Committee.
2. Fertilizer Committee.
3. Standardization of Field Plot Technique.

Considerable discussion resulted from the first suggestion. The question was raised as to the advisability of the Western Canadian Society of Agronomy appointing a Varietal Zonation Committee in view of the fact that such a committee has already been appointed by the Canadian Seed Growers' Association. It was finally moved by A. T. Elders and seconded by G. M. Stewart, that a resolution be passed requesting a representative of each of the three varietal zonation committees of the prairie provinces to get together to join up the map lines representing the different zones. It was requested that this group consider themselves a committee and that a report of their findings be made at the next annual meeting. Passed.

The members present agreed that symposiums be arranged for the next annual meeting on "Fertilizers" and on "Field Plot Technique."

The auditing committee reported on the Treasurer's Report. All accounts were reported correct with vouchers as far as available. It was pointed out that it was practically impossible to close the books at the time of the meeting and have all accounts settled. It was moved by S. Barnes and seconded by A. T. Elders that in the future the books be closed on February 1st following the annual meeting. Passed.

A brief report was made by the Secretary on the progress the Society had made during the past year. It was pointed out that members of the Western Canadian Society of Agronomy could join the Canadian Society of Technical Agriculture without the additional $5.00 initiation fee. Advantage was taken of this arrangement and a joint campaign was launched with J. M. Manson, Secretary of the Alberta branch of the Canadian Society of Technical Agriculturists, for new members in both organizations. The Secretary thanked the Society for the excellent support received from its members.

At the last annual meeting a ruling was passed making all Secretary-Treasurers who had served *at least one year,* life members. One case was called to the attention of the Society in which a past Secretary-Treasurer had not served a full year but had given all the usual service covered in a year in office. It was moved by A. E. Palmer, seconded by J. H. Ellis that the name be added to the list of life members. Passed.

A. W. Henry reported for the Membership Committee with a list of names of prospective members from Alberta and Manitoba. J. G. Taggart was to report for Saskatchewan at a later date.

A brief report received from the Curator, J. D. Newton, was read by the Secretary. It was pointed out that several hundred copies of the Proceedings of the Society for the years 1920-1924 inclusive were still available for distribution.

The following resolutions were presented for the Resolutions Committee by L. E. Kirk.

1. To Mrs. F. H. Grindley.
2. To Prof. J. P. Sackville, President, Canadian Society of Technical Agriculturists.
3. To Dr. R. C. Wallace, President, University of Alberta.
4. To the Outgoing Executive.
5. To those engaged in furthering the welfare of agriculture—re weed seed by threshers.
6. To National Research Council. Re alfalfa seed setting.
7. To World Grain Exhibition.

1. The members of the Western Canadian Society of Agronomy in session at Edmonton wish to express their pleasure that recent reports on Mr. F. H. Grindley's illness have been favourable, and to say how much they hope for his speedy recovery. They also wish him to know that his interest in this Society and services to agriculture are fully recognized and

greatly appreciated. Moved by L. E. Kirk, seconded by J. D. Newton. Passed.

2. The members of the Western Canadian Society of Agronomy in convention at the University of Alberta wish to express their pleasure at the recent favourable turn in your illness and to say they sincerely hope your recovery may be speedy and complete. They wish also to express their high appreciation of your services to agriculture, in particular to the Canadian Society of Technical Agriculturists with which this Society is affiliated. Moved by L. E. Kirk, seconded by J. H. Ellis. Passed.

3. Resolved that the Western Canadian Society of Agronomy appreciates very heartily the coöperation of the University of Alberta in providing accommodation to members of the Society for holding its tenth annual meeting, and also expresses its appreciation of the entertainment and courtesies extended to the Society. Moved by L. E. Kirk, seconded by H. G. L. Strange. Passed.

4. Resolved that a hearty vote of thanks be extended to the Secretary, O. S. Aamodt, and the outgoing executive for the excellent programme provided for the members of the Western Canadian Society of Agronomy at its tenth annual meeting, and expresses its appreciation of the service rendered to the Society during their terms of office. Moved by S. H. Vigor, seconded by G. M. Stewart. Passed.

5. The Western Canadian Society of Agronomy draws attention to the widespread distribution of noxious and other weed seeds by threshing machines—custom threshers—group threshers—individual threshers and particularly by combine threshers.

The Society is of the opinion that this harmful practice can be greatly decreased if not entirely eliminated. The Society therefore recommends to those who are engaged in furthering the welfare of agriculture that definite thought and study should be given to ways and means of inducing manufacturers to devise attachments for threshing machines that will separate and sack weed seeds from the grain being threshed.

The Society further recommends that the proper authorities might suggest a scale of remuneration per bushel of these weed seeds that will recompense threshermen for the extra work involved. Moved by H. G. L. Strange, seconded by E. C. Hallman. Passed.

6. The Western Canadian Society of Agronomy draws attention to the well known value of alfalfa as a most beneficial crop in grain crop rotations and in agriculture in general. The Society views with some concern the high cost of production and hence high price of alfalfa seed which undoubtedly is limiting the use of alfalfa, and is of the opinion that one reason for this high cost is the fact that alfalfa often does not set seed, the reasons for which have not been determined.

The Society is informed further that severe financial losses are sustained by those attempting to produce alfalfa seed because of the unreliability of seed setting. The Society is therefore of the opinion that a definite investigation of this matter should be undertaken, and it suggests that this problem

would provide a very suitable and useful project for the National Research Council. Moved by W. L. Jacobson, seconded by G. M. Stewart. Passed.

7. The Western Canadian Society of Agronomy in considering the proposed 1932 Exhibition at Regina is very anxious that the scientific presentation and discussion of important problems affecting agriculture shall receive the prominence which they deserve, and instructs the Secretary to bring their attitude on this matter to the attention of the officials in charge of the Conference. Moved by H. G. L. Strange, seconded by H. S. Fry. Passed.

8. The Western Canadian Society of Agronomy in considering the proposed 1932 World Grain Exhibition strongly indorses the principle of germination, verification and quality tests for wheat, oats and barley. Moved by H. S. Fry, seconded by J. G. Taggart. Passed.

G. M. Stewart reported for the Nominations Committee as follows:

Honorary Presidents:

President W. G. Murray, University of Saskatchewan.

President J. A. McLean, University of Manitoba.

President R. C. Wallace, University of Alberta.

Honorary Vice Presidents:

Dean E. A. Howes, University of Alberta.

Dean W. C. McKillican, Manitoba Agricultural College.

Dean W. J. Rutherford, University of Saskatchewan.

General Executive:

President—J. B. Harrington.

Vice-President—J. R. Fryer.

Secretary-Treasurer—A. T. Elders.

Curator—J. D. Newton.

Executive—K. W. Neatby and J. G. Taggart.

It was moved by W. H. Fairfield and seconded by J. H. Ellis that these men be elected. Passed.

J. H. Ellis presented an invitation from Dean McKillican that the Society hold its next annual meeting at the Manitoba Agricultural College. Accepted with applause.

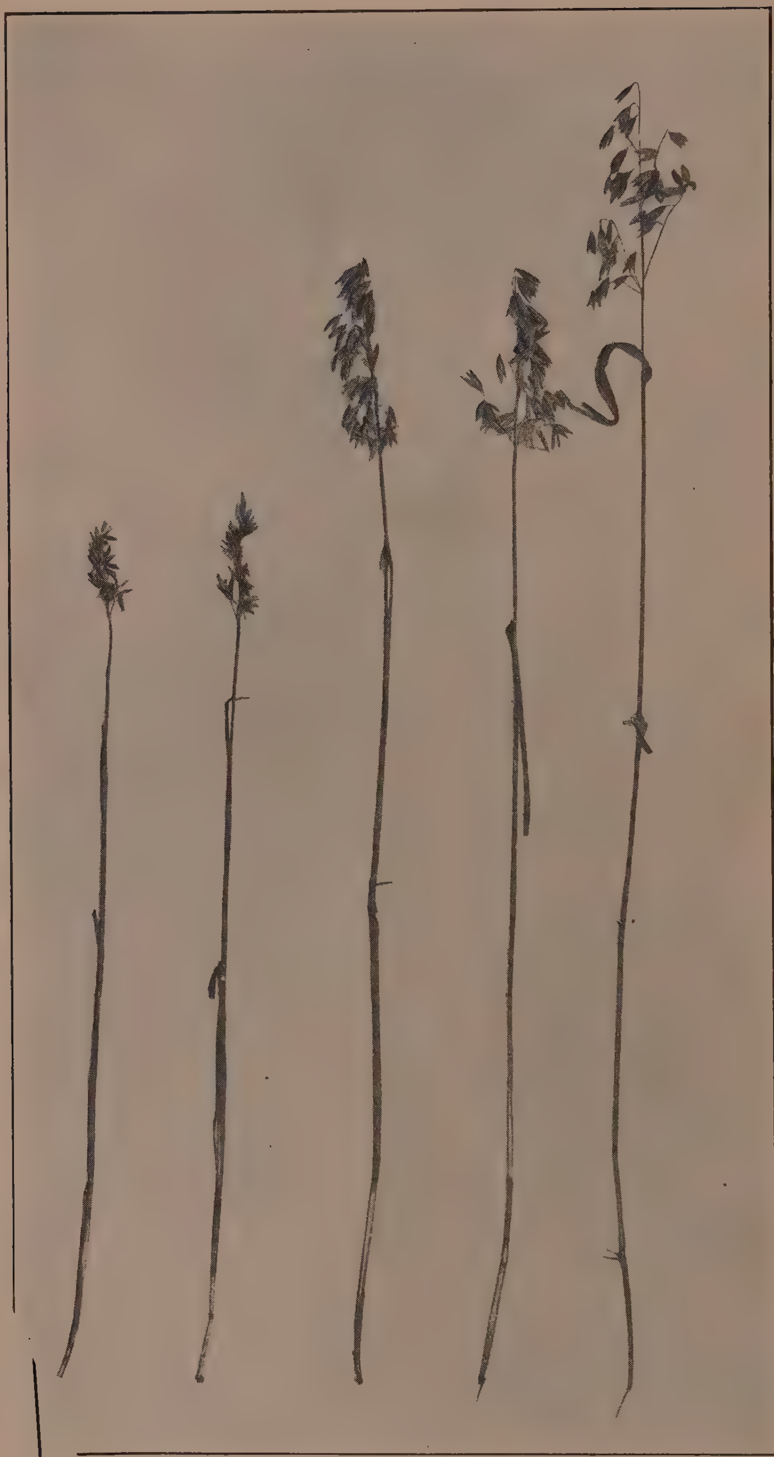
In the absence of President-elect, J. B. Harrington, the Vice-President, J. R. Fryer, took the chair for a few minutes, after which the meeting was brought to a close.

O. S. Aamodt,
Secretary.

A NEW "DWARF" OAT

Panicle characteristics of the "dwarf" segregant slightly magnified, showing peculiar glume forms and shortened panicle branches.

Note: See paper entitled "A New "Dwarf" Oat" which appeared in *Scientific Agriculture,* Volume X, No. 8, pages 539-542, for descriptive account of the above plate and the one on page 620.



Form of panicles and relative heights of the "dwarf," intermediate and normal segregants.

LA RESTITUTION BIOLOGIQUE DE L'AZOTE AU SOL

FERNAND CORMINBOEUF
Professeur au Collège de Gravelbourg, Sask.

(Continuation du mois d'avril)

I—CAUSES EFFICIENTES

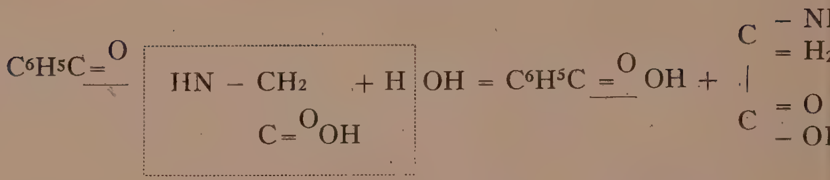
Notons avant d'aborder l'étude des causes que les différentes sources d'azote peuvent se ramener à deux—essentiellement distinctes—à savoir: l'atmosphère et la matière organique. La première livre l'azote sous forme minérale. Sous cette forme, l'azote doit pour pouvoir être assimilé par un végétal supérieur, subir au préalable la nitrification, phénomène d'ordre biochimique par lequel l'azote minéral est oxydé et partant susceptible de pénétrer dans la circulation sous forme d'ions nitriques devant servir dans le métabolisme végétal à la synthèse des albuminoïdes. Ce phénomène étant étroitement lié à la présence dans le sol et dans les organes d'absorption de la plantes de microbes aérobies, il importe de maintenir le sol dans les meilleures conditions possibles d'aération, d'humidité, ainsi que dans des conditions chimiques réalisant pour le mieux la réaction du milieu favorable au développement et à l'activité des microbes. Il en sera question en traitant des causes adjuvantes.

L'autre source importante—la matière organique—ne cède la totalité de son azote que lentement parce que celui-ci s'y trouve engagé sous une forme très complexe nécessitant tout d'abord une simplification progressive pour pouvoir nitrifier, nitrater, et enfin s'organiser.

Ce bref exposé nous conduit tout naturellement à l'étude de l'ammonisation, de la fermentation nitrique et des facteurs favorisant ou entravant ces phénomènes.

1. L'ammonisation ou fermentation ammoniacale consiste dans la transformation de l'urée ou autres composés analogues en carbonate d'ammonium par hydrolyse. Cette première étape de transformation de toute matière organique azotée est sous la dépendance de microbes aérobies spécifiques, le micrococus urea, qui affecte souvent la forme d'un streptococus, mais beaucoup d'autres microbes sont doués de cette propriété. Ce sont notamment des cocus, des sarcines, des uro-bacillus, des uro-cocus, des uro-sarcines (Kayser), ferments aérobies et anaérobies. C'est une fermentation banale, qui cependant, d'après Kayser, est plus active en conditions aérobies qu'en conditions anaérobies. Mais d'après Löhnes et Green, la nature chimique de la matière qui subit ce phénomène est d'importance majeure et suivant Myake la vitesse de transformation en ammoniaque est plus grande pour les dérivés animés de la série grasse que pour ceux de la série aromatique ou cyclique.

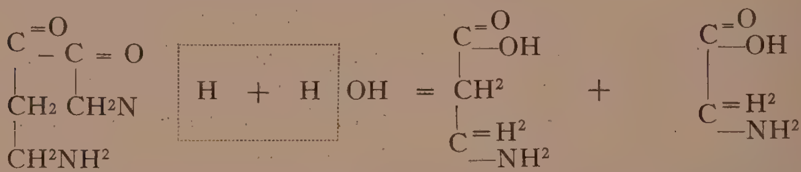
Comme exemple de composé cyclique, mentionnons l'acide hippurique ou amide benzoïque. Ce composé se dédouble par l'action hydrolysante du bacillus urea ou d'enzymes protéolytiques en acides phénylméthanoïque et aminoéthanoïque (glycocolle), suivant l'équation:

(1) 

Le glycocolle (dérive aminé) est susceptible de se transformer suivant l
équations (2) et (3) pour fournir de l'ammoniaque.

(2) $2C^2H^5NO^2 + 3O^2 = (NH^4)^2CO^3 + 3CO^2 + H^2O$ (V).

(3) $(NH^4)^2 CO^3 = H^2O + CO^2 + 2NH^3$.

(4) 

Parmi les composés de la série grasse citons à titre d'exemple le glycylalami
qui se dédouble par hydrolyse et dans les mêmes conditions en acide-amin
acétique et homologue: l'alamine, suivant l'équation:
L'alamine se transforme en carbonate neutre l'ammonium par oxydation
finalement en anmoniaque.

(5) $2C^3H^7NO^2 + 6O^2 = (NH^4)^2 CO^3 + 3H^2O + 5CO^2$ (V').
$(NH^4)^2CO^3 = CO^2 + H^2O + 2NH^3$.

Si V et V' respectivement, représentent leurs vitesses de transformation
ammoniaque, nous avons : $V < V'$.

La réaction alcaline du sol ainsi que l'élévation de température accro
sent singulièrement la vitesse de ces transformations. C'est pourquoi, da
cet ensemble de facteurs influençant l'ammonisation, il y a tout lieu de mett
en relief la part au moins des principaux d'entre eux afin d'en déduire qu
ques conséquences pratiques. Dans cet ordre d'idées, disons d'abord q
les jeunes plantes renferment la plus grande partie de leurs substanc
azotées sous forme de composés amidés, lesquels sont susceptibles de
transformer rapidement en ammoniaque, tandis que les plantes plus âgé
renferment surtout des albuminoïdes, composés plus complexes dont l'a
monisation est plus lente.

Se fondant sur ces considérations ainsi que sur l'influence de la tempé
ture et de le réaction du milieu, il est singulièrement plus avantageux d'e
fouir les engrais verts à l'automne. Si de plus, le sol est suffisament riche
calcaire les conditions d'une décomposition et d'une ammonisation rapic
seront réalisées. Lorsque l'enfouissement a lieu à l'automne, l'ammoniaq
formée persiste dans le sol pendant l'hiver car la température est trop ba
à cette période de l'année pour que cette base puisse s'oxyder et se chang
en acide nitrique, Mais il est fort probable que dès le printemps suivant ce
oxydation commence et l'ammoniaque se transforme en acide nitrique q
les végétaux semés à ce moment pourront utiliser.

2. La nitrification.—On sait actuellement que la plupart des plan
absorbent l'azote combiné à peu près complètement sous forme de nitra

en dissolution dans l'eau du sol. Ces nitrates résultent de la combination de l'azote nitrique issu de la nitrification avec les bases solubles du sol. Le phénomène de la nitrification est dû à l'activité de deux microorganismes distincts, l'un le nitrosomonas ou nitrococus transforme par oxydation l'ammoniaque en anhydride nitreux l'autre le nitromonas ou nitrobacter transforme, également par oxydation, l'anhydride nitreux en anhydride nitrique. Remarquons en passant que ces deux microbes sont spécifiquement distincts. Le premier n'agit que sur l'ammoniaque, le second n'opère que sur l'anhydride nitreux. Cependant, ils ont un caractère commun. Tous deux sont autotrophiques, c'est-à-dire qu'ils peuvent se développer dans l'obscurité et obtenir assez d'énergie et d'aliments—azote et carbone—de source organique. Mais pour qu'il y ait formation de nitrates, ces microbes requièrent sinon de la matière organique en voie de décomposition, du moins la présence de sels ammoniacaux à l'état de sulfates, carbonates ou chlorures.

II. Causes Adjuvantes

En dehors de la présence d'une matière azotée organique ou ammoniacale et de ferments nitreux et nitriques, le processus bio-chimique de la nitrification exige pour s'accomplir normalement la constance de certaines conditions nécessaires. L'oxygène et la chaleur étant indispensables à la décomposition de la matière azotée, plus une terre sera meuble, plus la formation des nitrates sera activée. Une légère alcalinité du sol est également indispensable ; la nitrification ne se fait pas dans les terres acides. Il faudra donc éviter sur de tels sols l'emploi d'engrais acides et donner la préférence aux sels normaux. De plus les amendements calcaires y seront nécessaires.

Conclusion

Etant donné ce qui précède, nous devons conclure :

1. Que l'atmosphère et la matière organique constituent deux sources naturelles et importantes d'azote :

2. Que le cultivateur est à même d'utiliser l'azote atmosphérique par la culture de plantes légumineuses telles que le trêfle d'odeur, la luzerne, etc ;

3. Qu'il est, de plus, à même d'utiliser l'azote de la matière organique provenant de l'enfouissement à l'automne d'engrais verts.

LITTERATURE CITEE

Cours de chimie physiologique vegétale (M. H. M. Nagant).
Microbiologie agricole (Kayser).
Plant Relations (Coulter).
Chimie du sol (André).
Microbiology (Con and Con).

REUNION A STE ANNE DE LA POCATIERE

Samedi dernier les Agronomes, les Techniciens et les Professeurs d'agriculture se réunirent à l'Ecole d'Agriculture de Sainte-Anne de la Pocatière pour entendre M. Rioux leur parler de:

la comptabilité agricole et les recherches d'économie rurale.

D'après M. Rioux, la science de l'organisation est le principal facteur de succès dans tous les domaines économiques. Pour réussir, un entrepreneur doit coordonner parfaitement les divers éléments de son exploitation. C'est ce travail intellectuel d'organisation qui conduit toute industrie vers sa fin: le plus fort profit possible.

Aucune industrie ne souffre autant que l'agriculture du manque d'organisation; aucune ne fabrique des produits aussi variés et ne met en jeu des éléments et des combinaisons de moyens aussi complexes.

Or, c'est l'économie rurale qui préside à l'organisation de l'agriculture.

a) Elle enseigne comment organiser et administrer les entreprises agricoles pour obtenir le maximum de profit;

b) Elle détermine les rélations ui doivent s'établir entre la ferme et l'extérieur.

L'économie rurale surpasse toutes les autre sciences agricoles.

a) Par son but, elle se propose d'organiser l'agriculture en général et chaque ferme en particulier pour tirer du sol le plus fort bénifice net;

b) Par son objet: elle embrasse toutes les activitées agricoles: politiques, sociales, techniques, professionnelles, industrielles et commerciales.

c) Par son objet; pour faire progresser l'agriculture, elle fait appel à toutes les sciences qui peuvent jouer un rôle dans la production agricole.

C'est la science ue devraient surtout approfondir les gouvernants qui doivant aider l'industrie agricole; les agronomes, qui ont pour mission d'organiser les fermes de leur district; les cultivateurs, pour exploiter leur entreprise de la manière la plus rémunératrice.

La ferme est l'usine agricole; elle fonctionne en vue du profit. Pour déterminer les conditions qui assurent le succès de l'industrie agricole, il faut analyser les résultats financiers d'un grand nombre d'exploitations dans chaque région: c'est le rôle de la comptabilité. C'est donc sur les méthodes comptables que l'économie rurale basera toutes ses recherches.

Le conférencier se borne à analyser la première loi d'économie rurale concernant l'administration des fermes; étant données les conditions physiques et économiques dans lesquelles il se trouve, le cultivateur doit organiser sa ferme pour retirer le plus fort profit net total des trois instruments de production qu'il met en oeuvre.

C'est grâce à la comptabilité qu'on a pu dégager ce principe. Des théoriciens avaient recommandé de choisir les entreprises qui rapportent soit le maximum de produits bruts, le plus fort rendement par unité animale, la plus grande valeur à l'acre, le plus fort bénifice par heure de travail, le plus

grand profit par acre multiplié par le nombre d'acres qu'un homme peut cultiver, etc... Ces mesures d'efficacité ne coïncident pas toujours avec le profit net maximum; la preuve en a été faite par la comptabilité.

Se plaçant au point de vue d'un cultivateur de la vallée de la Matapédia, le conférencier expose comment organiser sa ferme, choisir ses productions et les combiner en se guidant sur les lois de l'économie rurale, qu'il appliquera en utilisant les conclusions de sa comptabilité.

Des recherches d'économie rurale basées sur la comptabilité devraient être poursuivies dans toutes les parties de la province pour donner des directions au cultivateur et à tous ceux qui sont chargés de faire progresser l'agriculture. Il n'est pas un seul problème d'économie rurale qui ne puisse être résous plus facilement à l'aide de la comptabilité. Or, nous appliquons chez nous des principes d'économie rurale basés sur la comptabilité des fermes américaines et européennes, qui se trouvent dans des conditions très différentes des nôtres.

Le conférencier termine en suggérant la création d'un office de comptabilité agricole, comme ceux qui ont donné d'excellents résultats dans la plupart des pays. Il explique le fonctionnement de cet organisme qui deviendrait l'observatoire de notre service d'économie rurale.

M. Charles Gagné, professeur d'Economie Rurale à l'Ecole d'Agriculture, fut chargé de remercier le conférencier. Il en profita pour annoncer aux confrères de M. Rioux que ce dernier venait de passer avec grand succès sa licence ès Sciences Agricoles.

On profita de la réunion pour faire l'élection des nouveaux officiers: Furent élus:

Président: J. A. Godbout, M.P.P., professeur à l'Ecole d'Agriculture.

Vice-Président: Paul Carignan, agronome officiel du comté de Montmagny.

Sec-Trésorier: Elzéar Campagna, professeur à l'Ecole.

Les nombreux amis de M. Marcel Bonnier, agronome à Maniwaki lui offrent à l'occasion de son prochain mariage à Mlle Gertrude Mae Robinson, New Carlisle, leurs meilleurs voeux de bonheur et de prospérité.

Fungous Diseases of Plants *(in agriculture, horticulture and forestry)*.—By Jacob Eriksson. Second Edition. Translated from the German by Wm. Goodwin. Bailliere Tindall and Cox, London, 1930. Price 35/-.

Not so many years ago a man interested in plant pathology, experienced great difficulty in finding a position outside official services. Entomologists, however, were in demand. Today plant pathology may be justly regarded as a science that has come into its own. Anyone who has Eriksson's first English Edition on his library shelves will be astonished at the new edition just sent for review, the volume of which confirms the strides that have been made in this science. Eriksson, one of the remaining few veterans and pioneers of Europe in this science, is to be congratulated on his new edition, equally so his translator, who made the German text available to the English reader.

The volume—7 : 9½″—contains 526 pages and 399 illustrations (some of which might have been materially improved had they been printed from fresh cuts; blocking out background does not improve illustrations). The text presents a very useful review of the more important plant diseases of Northern and Middle Europe, with clear, though often very brief accounts of each. This review will be found extremely useful by any student or teacher of this science. The subject matter is appreciably up to date, the accounts of the bacterial diseases of plants occurring in Europe, will be much appreciated.

The outstanding merit of the book is the information to be gained on diseases as yet European, but which may at any time, in these days of rapid transit and commercial interchange, reach this side of the Atlantic. Forewarned is forearmed.

I note several instances where the excellent drawings of the late Worthington G. Smith, have been used, but were credited to W. C. Smith or M. G. Smith. No library can afford to be without this book and all plant pathologists will certainly feel indebted to Professor Eriksson for his continued and remarkably up to date researches on the fungus and bacterial diseases of economic plants.

Animal Breeding.—Second Edition. By Professor L. M. Winters. (John Wiley & Sons, Inc., New York, 1930).

When Professor L. M. Winters was connected with the University of Saskatchewan, he published in 1925 his first edition of "Animal Breeding". This work has proven a most useful addition to the shelves of students and live stock men,—as a text book to the former and as a reference volume and means of better understanding of the many breeding problems met with by the practical and experienced stockman. Since then the author has become associated with the University of Minnesota as Animal Breeder and Associate Professor of Animal Husbandry, and there has just come to hand a copy of his second edition of this work as published in 1930 by John

Wiley & Sons, Inc., New York. In his preface, Professor Winters states that in the preparation of the second edition of "Animal Breeding", his endeavour has been to make the text more comprehensive than in the case of the first, to correct such errors as may have occurred, and to include much of the recently published work pertaining to the rapidly broadening subject of animal breeding. A review of his latest work indicates that the author's endeavours have been entirely successful. Greater comprehensiveness, improved arrangement, a greater number of excellent illustrations, and the inclusion of much information acquired since the first edition was available, considerably enhance the value of the second edition as compared with its predecessor.

In his treatment of the more technical and scientific phases of the subject, the author has seemed to choose a happy arrangement whereby the significance and value of the scientific aspect, and, at the same time, the reader's interest and the readable qualities generally are both fully retained.

The second edition of "Animal Breeding" might very profitably be included in the collection of the practical or professional live stock man.

G. B. R.

THE CENTRAL EUROPEAN IMMIGRANT IN CANADA. By Robert England. (The Macmillan Company of Canada, Ltd., 1930. Price $2.00).

A book which will interest all Canadians concerned for the future of their country is "The Central European Immigrant in Canada," by Robert England, M.C., recently published by The Macmillan Company of Canada, Ltd. Although Mr. England's book would have been more accurately named "The Central European Immigrant in Saskatchewan" its subject matter is of national rather than provincial significance, and its conclusions are applicable to the whole Dominion.

The book discloses how the Masonic Grand Lodge of Saskatchewan contributed over $20,000 in scholarships to encourage highly qualified teachers to offer their services in certain of the backward and remote non-English school districts of rural Saskatchewan. Mr. England was one of those teachers and the impressions on which his book are based were therefore gained largely at first hand. Reports of other teachers have also been placed at his command and are extensively quoted.

From a general study in the first chapters of his book of the factors affecting immigration the author comes to grips with the actual situation found in certain portions of Saskatchewan. Little space is spent on the British, American, or Scandinavian immigrant; undoubtedly these were outside the field of the present study, but the impression is left that they present little or no problem. The same seems to apply to the French and the German. That the Central European immigrant does present a problem the author is firmly convinced. This does not suggest racial inferiority, but racial differences, and absence of effective lines of communication between the Central European immigrant and the older Canadian population. The author makes plain, also that the problem is not presented by the immigration of recent years but by the "inferior material admitted prior to the war".

The solution is found in the rural school, but it is not suggested that tl rural school, left to itself, will solve the problem. A call is made for teache possessing not merely academic qualifications but embodying in themselv a fine standard of Canadian personality. "Mere literacy is no criterion usefulness in the modern world....the school....must inform and strengthe judgment and break down the disrepute into which farm labour is falling."

Altogether, an instructive and interesting book, and one likely to sho us somewhat out of our self-complacency, which makes it all the mo valuable.

R. J. C. S.

Dominion Department of Agriculture Library

Members of the C. S. T. A. who avail themselves of the lending faciliti provided by the Dominion Department of Agriculture Library at Ottav will be interested in the following figures, showing the number of boo sent out on loan to C. S. T. A. members during the fiscal year ending Mar 31, 1930.

PROVINCE	Number of Borrowers	Publications Borrowed			Tota loans
		Books	Period-icals	Inter-library loans	
Ontario (exclusive of Ottawa)	158	1059	206	46	13
Quebec	150	957	127	10	10
Prince Edward Island	10	139	163	4	3
New Brunswick	21	124	226	1	3
Nova Scotia	29	207	411	7	6
Manitoba	71	329	241	20	5
Saskatchewan	62	330	234	27	5
Alberta	80	258	133	45	4
British Columbia	59	505	164	7	6
United States	7	50	2	1	
Total	647	3958	1907	168	60

C. S. T. A. Officers 1930-31

Just as we go to press the results of the election of officers, conduct by mail ballot during the month of April, can be announced. They are follows:

President: W. T. Macoun.

Vice-Presidents: H. S. Arkell, Georges Bouchard, M.P. (re-elected).

Honorary Secretary: L. H. Newman (re-elected by acclamation).

The ballots were opened on April 30th. 776 Members voted.

The new officers assume their duties at the close of the Wolfville co vention.

CONCERNING THE C.S.T.A.

Notes and News

J. B. Fairbairn, Beamsville, Ont., has been appointed Deputy Minister of Agriculture for Ontario. W. B. Roadhouse, who has been Deputy Minister since 1912, has resigned in order to accept the Chairmanship of the Ontario Agricultural Development Board.

A. R. Milne (McGill '21), formerly Assistant to Continental Superintendent of the Canadian National Railways Department of Colonization, with headquarters in London, England, has received the appointment of Continental Superintendent.

E. M. Taylor (McGill '18) has resigned the position of Assistant Superintendent at the Dominion Experimental Station, Fredericton, N. B., to become Field Husbandman, Soils and Crops Division, Department of Agriculture, Fredericton, N. B.

C. L. Huskins (Alberta '23), Research Geneticist and Cytologist at the John Innes Horticultural Institution, London, England, is returning to Canada about September 1, 1930, to take up his new duties as Associate Professor of Botany at McGill University, Montreal, P.Q.

I. F. Stothers (Toronto '23), formerly Dairy Inspector under the Saskatchewan Department of Agriculture, is now Loan Officer with C. S. Gunn Company, Limited, Saskatoon, Sask.

G. R. Paterson (Toronto '24), recently appointed Agricultural Fieldman for the American Cyanamid Company, has changed his address to Norfolk Apartments, 245 Woolwich Street, Guelph, Ont.

J. R. Proulx (Laval '22) has been appointed Professor of Animal Husbandry at the Agricultural College, Ste. Anne de la Pocatière, P. Q.

D. S. Kaufman (Manitoba '27) has changed his address to Suite 10B Balfouria Apartments, Winnipeg, Man.

C. A. Perrault (McGill '26) has been appointed Plant Pathologist at the Dominion Laboratory of Plant Pathology, Ste. Anne de la Pocatière, P. Q.

Rozemond Caron (Laval '25) has received the appointment of Junior Supervisor of Illustration Stations for Eastern Quebec, with headquarters at the Dominion Experimental Station, Ste. Anne de la Pocatière, P. Q.

K. C. Thorneloe (British Columbia '28) is taking graduate work in the Dairy Industry Department, Iowa State College, Ames, Iowa, U. S. A.

Raoul Dionne (Laval '18) has been appointed District Co-operative Live Stock Marketing Promoter under the Dominion Live Stock Branch. His mailing address is P. O. Box 10, Rimouski, P. Q.

G. H. Robinson (Saskatchewan '29) is taking graduate work at the University of Minnesota. His mailing address is 2117 Dudley Avenue, St. Paul, Minn., U. S. A.

F. F. Baird (Toronto '28) has been appointed Sheep and Swine Promoter under the Dominion Live Stock Branch with headquarters at Charlottetown, P. E. I.

C. E. St. Marie (McGill '28) has been transferred from the Dominion Fruit Branch in Montreal to the Experimental Farms Branch at Ottawa. His mailing address is Apartment 4, 404 Elgin Street, Ottawa, Ont.

Robert Broadfoot (Manitoba '23) has joined the staff of the Dominion Seed Branch at Winnipeg. His mailing address is Suite 5, Brantford Apartments, Ellice Avenue, Winnipeg, Man.

H. N. Racicot (McMaster '21), Plant Pathologist under the Dominion Experimental Farms Branch, has been transferred from Ste. Anne de la Pocatière, P. Q., to the Central Experimental Farm, Ottawa, Ont.

Aurele Hebert (Laval '27) has changed his address to St. Agapit, Lotbiniere Co., P. Q.

C. A. Zavitz (Toronto '88), who has been spending the winter months in Florida, has returned to his home at R. R. No. 2, Ilderton, Ont.

P. M. Daly (McGill '21) has changed his address to 31 Dorchester Street, St. John, N. B.

A. W. Mackenzie (Toronto '23) has been appointed Superintendent of Agriculture and Colonization for the Canadian National Railways, with headquarters at Moncton, N. B.

A. W. Aylard (British Columbia '25) has changed his address to R. M. D. 1, Sidney, B. C.

Paul Langlois (Laval '20), Sheep and Swine Promoter under the Dominion Live Stock Branch, has been transferred from Rimouski to Murray Bay, P. Q.

C. A. Cline (Toronto '22) has been appointed salesman for the Burlington Steel Company, Burlington, Ont.

Applications for Regular Membership

The following applications for regular membership have been received since April 1, 1930:

Atkinson, L. A. (British Columbia, 1925, B. S. A.) Vancouver, B. C.

French, H. S. (Toronto, 1916, B.S.A.) Courtenay, B. C.

Hall, E. R. (Toronto, 1915, B.S.A.) Saanichton, B. C.

Vacancies in Dominion Department of Agriculture

The Civil Service Commission at Ottawa is advertising the following vacancies in the Dominion Department of Agriculture. Applications should be addressed to the Secretary of the Commission.

Assistant Chemist. Initial salary $2,220 per annum up to a maximum of $2,700. To be attached to the Seed Brand at Ottawa. Applications must be filed not later than May 29, 1930.

Assistant Plant Pathologist. Initial salary $2,040 per annum up to a maximum of $2,400. To be located at the Dominion Rust Research Laboratory, Winnipeg, Man. Applications must be filed not later than May 29, 1930.